The AMSAT® Journal

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AMSAT Announcements

The 2008 AMSAT Space Symposium will be held in Buckhead (Atlanta) GA on Friday, October 24th. The hotel is the Double-tree (a member of the Hilton Honors family) . It is 10 minutes from downtown Atlanta and adjacent to the Buckhead MARTA Rail Station. The room rate is $125 for one or two people, $135 for three and $145 for four. For those that complained this year about an airport hotel, this one is for you! Start making your plans now.

Due to the number attending this year's Symposium, we have no 2007 Proceedings in stock. We are working on a Symposium CD which will contain the papers in the Proceedings AND the pre-sentations. The CD should be available next month. Stay tuned!

Martha

AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.

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AMSAT's Future Is What You Make It

At this year's Annual Meeting, and in the last Apogee View column, I reported that AMSAT's future in space may be determined by the willingness of major outside funding sources to contribute to our projects. As a result I suggested that the only projects that would likely be successful are those with strong support for education or emergency communications, especially in North America. This is only partly true. AMSAT's future will also be determined by the desires and actions of those members who commit time and energy to AMSAT to see their dreams come true.

I am very pleased to report that AMSAT has attracted some sorely needed new volunteers. One of these, Joel Miller, W2TQ, has been taking the lead in crafting ITAR documentation to help AMSAT comply with US government regulations relating to the export of satellite technology so that we can continue working effectively with our international partners. Two other new volunteers, Dan Briner, AB3EN, and Steve Kenwolf, WH6BSZ, are beginning the task of forming a marketing department for AMSAT. These members represent the kind of personal commitment that will make AMSAT a strong organization far into the future.

If you have ideas on what you think AMSAT should become in the future then I encourage you to get personally involved and actively promote and support AMSAT in any way you can. You can write an article or a short column for *The AMSAT Journal*. If you are in the Washington DC area Martha needs help in the office with computers, stuffing envelopes, organizing archives and many other tasks. We have a number of software and Internet related projects. We need more help at the AMSAT Lab. We need RF, analog, digital, communications and software engineers. We need PC board layout experts. We need more Elmers to join the Field Operations Team. What skill do you have? We need that too!

Software Volunteer Needed

AMSAT's Treasurer Gunther Meisse, W8GSM, commissioned a project that we call AIMS or the AMSAT Information Management System. This is a database project that will provide secure access to important organizational data using the power of secure Internet communications to overcome the problems associated with the geographical diversity of our management teams. AIMS will also open up the possibility of providing "member only" services. The project is nearly complete after years of dedicated design and development work by Emily Clarke, N1DID. AIMS now needs a software engineer to complete the testing, debugging, fielding and maintenance of this important software package. This database is hosted on a Linux or FreeBSD computer and accessed using a Web browser. The skills that are required include vi or EMACS, MySQL, PHP, CSS and HTML forms. If you would like to work on this challenging project, contact Gunther at W8GSM@amsat.org or me at W2GPS@amsat.org.

AMSAT Institute

In the last Apogee View I described the outline for an AMSAT Institute, a "summer camp" for teachers and others focused on the AMSAT Lab in Maryland. AMSAT's Executive VP Lee McLamb, KU4OS, and Director of Education Paul Shuch, N6TX, have been working to better define this concept and form a workable plan. A few of you have volunteered to be a part of this activity. There are substantial problems associated with a significant undertaking like this but I believe the goals are worth the effort. If you are a "glass half full" type of person, we need you on this project. What I mean by that is the kind of person who will help us identify and overcome the obstacles to make this dream a reality. There is plenty of support available from AMSAT, the University of Maryland Eastern Shore and the Hawk Space Institute. It has been suggested that we could do a balloon launch for next summer's program. Let us know what you think and how you could help.

Donations

Many of you have rushed to get in your donations before the end of the year for tax purposes and I thank you for that. However, I need to remind you that AMSAT needs your continued financial support especially in the next few months. These are the months that

Apogee View continues on page 29 ...

Learn DSP By Programming Your PC, Part 3

by Richard F. Crow, N2SPI, n2spi@amsat.org

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Introduction

In Part 1, a C programming environment was established and additional reading was suggested. In Part 2, a C program was created which produced sine wave signal samples outputted through the sound card. In this part, we'll build on Parts 1 and 2 to create the software for a convolution-based, 3 kHz FIR low pass filter, which we'll insert between the sine wave samples and the sound card output. Listening to the sound card's speakers, we'll vary the frequency of the sine wave samples to test the filter. And finally, DSP in general and convolution-based filters in particular, will be discussed. Before continuing, it's strongly recommended you read Part 1 in the July/August 2007 *AMSAT Journal*, and then Part 2 in the September/October 2007 *AMSAT Journal*. I assume you'd like to see the filter working right away, so I'll focus on writing software first.

Step 1: Make a New Folder, Copy Files

Right now, boot up your PC, open a DOS window, and navigate to "c:\dm849c\dm\bin". Next, use the DOS command "md" to make a new subdirectory (folder) named "LPF1". Then, copy the files make2.bat, d2a.rc, and d2a.c from c:\dm849c\dm\bin\D2A\stage5 into c:\dm849c\dm\bin\LPF1 and rename them make3.bat, lpf1.rc, and lpf1.c respectively. Now, edit make3.bat to replace "make2.bat" in line 001 with "make3.bat", "d2a.rc" in line 009 with "lpf1.rc", and "d2a.c" in line 010 with "lpf1.c". Also, delete the comments in line 004 and 005. When done, make3.bat in ...\bin\LPF1 should look like Figure 1.

Next, edit lpf1.rc to replace all 8 occurrences of "d2a", in lines 001, 002, 003, 008, 009, 010, 015, and 019, with "lpf1". Also, edit the caption text in line 019 as shown in Figure 2. When done, lpf1.rc in ...\bin\LPF1 should look like Figure 2.

And finally, edit lpf1.c to replace all 5 occurrences of "d2a", in lines 001, 008, 009, 010, and 022, with "lpf1". Also, update the "Description:" in lines 002, 003, and 004. When done, the first 22 lines of lpf1.c should look like Figure 3. Now run make3.bat just to make sure everything still compiles OK. Then run lpf1.exe to make sure it works just like d2a.exe did before.

Step 2: Create Filter Software

Navigate to "c:\dm849c\dm\bin\LPF1" to edit lpf1.c. First delete everything in lpf1.c between lines 221 and the end of the program. Then, create the filter software by typing the code in Figure 4 (both pages of it) into lpf1.c starting with line 222 and ending with line 340. Note that I unrolled several software loops into inline code to make it easy to see how this convolution-based algorithm works. What it's doing is explained in the section on demystifying convolution-based filters below. Also, note that we're "multiplying" and "accumulating", over and over, starting in line 273. Thus, you can see why a fast MAC (multiply and accumulate) instruction is so important to DSP.

When done, save lpf1.c in "...\bin\LPF1", run make3.bat, and execute lpf1.exe. Again, you should see the familiar dialog box and hear the initial 5000 Hz burst. The initial burst isn't processed through the 3 KHz low pass filter, so it should be just as loud as before. After that, however, sine wave data is passed through the filter, so you should notice a drop in sound level. Experiment with different frequencies to see which pass unaltered, and which do not.

Step 3: Download a Filter Tool

Now that you have DSP filter software, you'll probably want to experiment with it. Essentially, the array h[ ] is a sampled version of the filter's impulse response which you "computer-convolve" with the sampled input signal, pIn[ ], to produce the sampled, filtered output, pOut[ ]. In DSP lingo, the h[ ] array is called the "filter kernel", its number of elements is the number of "taps", and the elements, taken individually, are "filter coefficients". Generally speaking, the more taps, the better the filter performance, and the slower the software runs. To create a different filter, say, a 3 kHz high pass or 10 kHz low pass you don't change the filter algorithm, you change the kernel. If you know how, you can generate your own kernels. But until then, I recommend you acquire a filter tool.

The filter tool I've selected is ScopeFIR. To download a free, trial version, go to "http://www.iowegian.com/download/loadfir.htm" and download "ScopeFIR411.zip". After unzipping it, locate "ScopeFIR.exe" and execute it. When you're asked to "Create or Open a ScopeFIR Project", select "Windowed Sinc" for now. Then, for example, if you wanted to recreate the filter kernel used here, enter 44100 Hz for the "Sampling Frequency ", 31 for the "Number of Taps", and select Blackman-Harris-4 for the "Window Type". Next, select Low pass for the "Filter Type", 3000 Hz for the "First Corner (Frequency)", and press the "Design" button. After that, right click inside the filter-coefficient-window (to the right), click "Select Filter and Data Format...", set "View Coefficients:" to Inphase, and click "Text:Hex" to get the filter coefficients in the hexadecimal format used here. In

```
REM Filename:     Make3.bat, version 1.0
REM Description:  Compiles .res resource file from .rc resource script.
REM               Then, compiles .c source file and links it using the specified options
REM Programmer:   Richard F. Crow, N2SPI, August 29, 2007
echo on
cls
C:\dm849c\dm\bin\rcc lpf1.rc -32
C:\dm849c\dm\bin\dmc lpf1.c winmm.lib comctl32.lib -mn -WA -L/RC -L/SUBSYSTEM:WINDOWS:4.0
pause
```

Figure 1: Make3.bat for lpf1.rc and lpf1.c

```
//001) Filename:        lpf1.rc, version 1.0
//002) Description:     Resource script to make lpf1.res resource file
//003)                  that goes with lpf1.c, a Windows XP program that
//004)                  implements a 3 KHz FIR lowpass filter (LPF)
//005) Programmer:      Richard F. Crow, N2SPI, August 29, 2007

                                    //007)(this line reserved)
#define IDC_TEXT1       1000        //008)(must match same #define in lpf1.c)
#define IDC_TEXT2       1001        //009)(must match same #define in lpf1.c)
#define IDC_SCROLL 1002             //010)(must match same #define in lpf1.c)

#include<windows.h>                 //012)(preprocr inserts text in".h"files..
                                    //013)...so pgm gets needed'C'definitions)

lpf1_resources DIALOG DISCARDABLE 100, 100, 200, 50

STYLE WS_MINIMIZEBOX | WS_VISIBLE | WS_CAPTION | WS_SYSMENU

CAPTION TEXT("LPF1, v1.0: Implements a 3 KHz FIR LPF")

FONT 8, TEXT("MS Sans Serif")

BEGIN
      CTEXT TEXT("Sine Wave Generator"),  IDC_TEXT1,  60, 4,  80,  8
      CTEXT TEXT("Frequency:  5000 Hz"),  IDC_TEXT2,  60, 14, 80,  8
      SCROLLBAR                           IDC_SCROLL, 10, 28, 180, 12
END
```

Figure 2: lpf1.rc

this trial version, you can't copy or save coefficients, so you'll have to copy them by hand. To do more, first read all the chapters in reference [4] up to and including chapter 16, "Windowed-Sinc Filters". Then, follow the ScopeFIR tutorial and read the ScopeFIR documentation.

DSP Demystified

So, what is DSP? Well, that's too big a question right now. Instead, let's break it into smaller pieces. Consider that at the heart of a DSP system is some sort of digital signal processor. So, what is a digital signal processor? Well, most of you are familiar with an ordinary four-function calculator that adds, subtracts, multiplies and divides. So, one colorful definition is: a digital signal processor is a four-function calculator on steroids. In other words, it's a math engine. A very, very fast math engine directed by a stored program.

How can a math engine process analog audio and radio signals? Well, for roughly a hundred years now, while some were developing analog circuits, such as amplifiers, filters, modulators and demodulators, other scientists and engineers were developing mathematical models for this technology. Eventually, there were not only obvious math models for amplification and attenuation, but more complex ones for filtering, modulation and demodulation, to name a few. Now, input signals could be represented as an ordered sequence of numbers, which could be mathematically manipulated by a model of some process, so as to produce another sequence of numbers, an output signal. Not too long after digital computers were invented, engineers could process signals digitally. But those old computers were huge, power-hungry and slow. It took hours, if not days, to process a few minutes worth of signal. It's only recently, as digital computers where reduced to the size of a chip and their speed was increased by orders of magnitude, that real-time digital signal processing in everyday products was made possible.

So let's try this out. Let's connect an analog signal to a digital signal processor's I/O (input/output) pin, programmed as an input, and monitor another I/O pin, programmed as an output, and see what happens. ...Nothing! Maybe our signal is too weak. Let's amplify it and try again. ...Nothing. No matter how much we amplify the signal, nothing (useful) happens. What's the problem??!!

Before we can answer that, we need to review the nature of analog signals. Generally speaking, all signals in this world start out as analog, such as from a microphone or antenna, and end up as analog, such as to a speaker or antenna. One waveform that embodies the analog concept is the sine wave. Right now, picture a continuous, analog sine wave voltage at some reasonable frequency plotted on an XY graph. The X-axis represents the time variable, in units such as microseconds, and the Y-axis represents the corresponding magnitude, in units such as millivolts. This is the proverbial time domain representation of a signal, which is epitomized by an instrument known as the oscilloscope. (If you have any difficulty understanding the time domain concept, beg, borrow or buy an oscilloscope and learn how to use it. In a sentence, anything in working order with "Tektronix" on it will do. If nothing else, it'll pay for itself when it displays signals coming out of your sound card beyond your range of hearing.)

The analog signal is a continuous signal, an infinitely continuous signal. By infinitely continuous, I mean that if you locate any two time points on the X axis, say, points t1 and t3 that correspond to time points in the sine wave, I can show you another time point, t2, that lies between these two points, which is also a time point in the sine wave. Furthermore, I can go on to show you two more time points, one between t1 and t2, and another between t2 and t3, and so forth, and so forth, ad infinitum. Not only is the time dimension infinitely continuous, the

```
//001) Filename:        lpf1.c, version 1.0
//002) Description:     A DSP program for Windows XP that generates sine
//003)                  wave samples and outputs them through a 3 KHz
//004)                  FIR lowpass filter (LPF) to sound card output
//005) Programmer:      Richard F. Crow, N2SPI, August 29, 2007

                                    //007)(this line reserved)
#define      IDC_TEXT1   1000       //008)(must match same #define in lpf1.rc)
#define      IDC_TEXT2   1001       //009)(must match same #define in lpf1.rc)
#define      IDC_SCROLL  1002       //010)(must match same #define in lpf1.rc)

#include<windows.h>                 //012)(preprocr inserts text in".h"files..
#include<math.h>                    //013)...so pgm gets needed'C'definitions)

#define SAMPLE_RATE      44100      //015)("#define" alias NAME for...
#define TWO_PI           6.28318    //016)                        ...text to replace it)
#define MIN_FREQ   20               //017)
#define INIT_FREQ  5000             //018)
#define MAX_FREQ   20000            //019)(in units of Hz)
#define BUFFER_SIZE      4096       //020)(size in bytes is 2*BUFFER_SIZE )

TCHAR szTemplateName[] = TEXT( "lpf1_resources" ); //declare globals

//** Lines 023 to 221 that follow are identical to those in d2a.c **
```

Figure 3: The first 22 lines of lpf1.c

magnitude dimension is infinitely continuous as well.

So, back to the problem of the analog signal connected to the digital signal processor. As it turns out, there are several problems. The first problem is the infinitely continuous nature of the analog signal's time dimension. If we're to process a signal time-point by time-point, this implies that the digital signal processor has to process infinite points in finite time. Well, sorry, but there ain't no digital processor in the known universe that can do that. The solution to this problem is called "sampling". First, we must sample the analog signal to transform infinite time-points into finite time-points. By sampling, I mean we'll take a snapshot of the signal's instantaneous magnitude at regular time intervals, say, every 22.7 microseconds for example. The device that does this sampling is called an A/D (Analog to Digital) converter. Note that sampling creates distortion as the sampled version only approximates the original analog signal. Specifically, sampling of an arbitrary analog signal results in loss of signal content above a certain frequency limit. However, we can reduce this distortion to insignificance if we can make the interval between samples sufficiently short. In other words, for a typical DSP system, the more samples per second, the higher the DSP system's frequency response.

The second problem, similar to the first, is due to the analog signal's infinitely continuous magnitude. Similarly, there ain't no digital computer that can represent an infinite number of voltage or current points with the finite number of binary bits in the "word length" for a given number representation scheme. The solution to this is called "quantization". We must quantize the analog signal to transform an infinite number of possible voltage or current values into a finite number of values. The device that performs quantization is, again, the A/D converter. By quantization, I mean an A/D will take a some range, say 0 to 1 volts, divide it uniformly into a finite number of sub-ranges, and then at sampling time, decide which sub-range most closely matches the instantaneous magnitude of an incoming signal. For example, a 3-bit A/D would take a 0 to 1 volt range and divide it up into 8 sub-ranges. In this case, sub-range level_0 would cover from 0.000v to 0.124v, sub-range level_1 from 0.125v to 0.249v, and so forth until the last, sub-range level_7, would cover 0.875v to 0.999v (virtually 1 volt). Then, if an incoming signal rose and fell in a triangle waveform from 0 to 0.51 to 0 volts over nine sample periods, this 3 bit A/D would classify it as the sequence: level_0, level_1, level_2, level_3, level_4, level_3, level_2, level_1, and level_0. Note that quantization introduces another type of distortion as it further approximates the original signal. This distortion shows up mainly as additional background noise in the quantized signal. Although we can't eliminate this distortion, we can reduce it to insignificance if we can use an A/D with a sufficient number of bits of resolution.

The third, and final problem is that digital processors, including DSP processors, understand binary numbers, not multiple voltage levels, quantized or not. To solve this problem we need to encode the quantized voltage levels into corresponding binary numbers. In my view, this is not covered well in the DSP literature. Some texts lump this process in with quantization. Others don't mention it at all. Again, the device that performs this encoding is the A/D converter. By "encode", I mean quantization level level_0 is assigned the binary number 0, level_1 is assigned binary 1, level_2 binary 2, and so forth until all sequential quantization levels are assigned sequential binary numbers. If negative voltages are quantized, level_-1 is assigned binary number -1, level_-2 is assigned -2, and so forth. In the end, we have a continuous range of binary numbers that are proportional to the magnitude of the input signal.

Now we've got a ball game! To summarize, a DSP system needs an A/D converter to sample, quantize, and encode an analog signal at its input so as to create an ordered sequence of binary numbers that the DSP processor can deal with. These binary numbers are known as input samples. Generally, what is inputted to a DSP algorithm are these input samples.

```
//============================== Line 221 ============================
void DigitalSignalProcessing( PSHORT pIn, PSHORT pOut )
{
      // Creates 31 tap, Windowed-Sinc, convolution-based 3 KHz LPF
      // (This version uses fixed-point, integer arithmetic for speed)
                                              //226)declare local variables:
      int   i;                                //227)=index var 4 pIn/pOut bufrs
      LONG        Acc[ BUFFER_SIZE + 30 ];    //228)=accumulator, pIn responses
      static LONG LeftOver[ 30 ];             //229)=buffr 4 left over Acc data
      SHORT       h[31]=                      //230)=array,3KHz LPF ImpulseResp
      {
            0x0000, 0x0000, 0xFFFE, 0xFFF7, 0xFFE5, 0xFFC8, 0xFFAE, 0xFFBE,
            0x003F, 0x0184, 0x03CB, 0x0711, 0x0AF3, 0x0EB4, 0x1172,
            0x1273,
            0x1172, 0x0EB4, 0x0AF3, 0x0711, 0x03CB, 0x0184, 0x003F,
            0xFFBE, 0xFFAE, 0xFFC8, 0xFFE5, 0xFFF7, 0xFFFE, 0x0000, 0x0000
      };

      Acc[ 0] = LeftOver[ 0];                 //239)init Acc with Acc data...
      Acc[ 1] = LeftOver[ 1];                 //240)...left over from last time
      Acc[ 2] = LeftOver[ 2];
      Acc[ 3] = LeftOver[ 3];                 //242)(Note: there may be a "pop"
      Acc[ 4] = LeftOver[ 4];                 //243)sound when start up because
      Acc[ 5] = LeftOver[ 5];                 //244)the LeftOver[] buffer is
      Acc[ 6] = LeftOver[ 6];                 //245)not initialized)
      Acc[ 7] = LeftOver[ 7];
      Acc[ 8] = LeftOver[ 8];
      Acc[ 9] = LeftOver[ 9];
      Acc[10] = LeftOver[10];
      Acc[11] = LeftOver[11];
      Acc[12] = LeftOver[12];
      Acc[13] = LeftOver[13];
      Acc[14] = LeftOver[14];
      Acc[15] = LeftOver[15];
      Acc[16] = LeftOver[16];
      Acc[17] = LeftOver[17];
      Acc[18] = LeftOver[18];
      Acc[19] = LeftOver[19];
      Acc[20] = LeftOver[20];
      Acc[21] = LeftOver[21];
      Acc[22] = LeftOver[22];
      Acc[23] = LeftOver[23];
      Acc[24] = LeftOver[24];
      Acc[25] = LeftOver[25];
      Acc[26] = LeftOver[26];
      Acc[27] = LeftOver[27];
      Acc[28] = LeftOver[28];
      Acc[29] = LeftOver[29];
      Acc[30] = 0;                            //269)will use this too, so init

      for(i=0 ; i<BUFFER_SIZE ; i++)          //271)loop thru pIn & calc scaled
      {                                       //272)resp from each scaled pIn[]
            Acc[i]       = Acc[i] + pIn[i] * h[ 0]; //scaled RespSampl@h[0]
            Acc[i+ 1] = Acc[i+ 1] + pIn[i] * h[ 1];   //scaled RespSampl@h[1]
            Acc[i+ 2] = Acc[i+ 2] + pIn[i] * h[ 2];   //scaled RespSampl@h[2]
            Acc[i+ 3] = Acc[i+ 3] + pIn[i] * h[ 3];   // etc. ...
            Acc[i+ 4] = Acc[i+ 4] + pIn[i] * h[ 4];
            Acc[i+ 5] = Acc[i+ 5] + pIn[i] * h[ 5];
            Acc[i+ 6] = Acc[i+ 6] + pIn[i] * h[ 6];
```

Figure 4: DigitalSignalProcessing()

```
            Acc[i+ 7] = Acc[i+ 7] + pIn[i] * h[ 7];
            Acc[i+ 8] = Acc[i+ 8] + pIn[i] * h[ 8];
            Acc[i+ 9] = Acc[i+ 9] + pIn[i] * h[ 9];
            Acc[i+10] = Acc[i+10] + pIn[i] * h[10];
            Acc[i+11] = Acc[i+11] + pIn[i] * h[11];
            Acc[i+12] = Acc[i+12] + pIn[i] * h[12];
            Acc[i+13] = Acc[i+13] + pIn[i] * h[13];
            Acc[i+14] = Acc[i+14] + pIn[i] * h[14];
            Acc[i+15] = Acc[i+15] + pIn[i] * h[15];
            Acc[i+16] = Acc[i+16] + pIn[i] * h[16];
            Acc[i+17] = Acc[i+17] + pIn[i] * h[17];
            Acc[i+18] = Acc[i+18] + pIn[i] * h[18];
            Acc[i+19] = Acc[i+19] + pIn[i] * h[19];
            Acc[i+20] = Acc[i+20] + pIn[i] * h[20];
            Acc[i+21] = Acc[i+21] + pIn[i] * h[21];
            Acc[i+22] = Acc[i+22] + pIn[i] * h[22];
            Acc[i+23] = Acc[i+23] + pIn[i] * h[23];
            Acc[i+24] = Acc[i+24] + pIn[i] * h[24];
            Acc[i+25] = Acc[i+25] + pIn[i] * h[25];
            Acc[i+26] = Acc[i+26] + pIn[i] * h[26];
            Acc[i+27] = Acc[i+27] + pIn[i] * h[27];
            Acc[i+28] = Acc[i+28] + pIn[i] * h[28];
            Acc[i+29] = Acc[i+29] + pIn[i] * h[29];
            Acc[i+30] = Acc[i+30] + pIn[i] * h[30];
            Acc[i+31] = 0;                              //304)will use next time, so init
            pOut[i]   = Acc[i] / 32768;                 //305)Acc[i], for current "i",...
      }                                                 //306)..will not be referenced...
                                                        //307)...again, so harvest it
      LeftOver[ 0] = Acc[BUFFER_SIZE  ];
      LeftOver[ 1] = Acc[BUFFER_SIZE + 1];              //data for these Accumulator
      LeftOver[ 2] = Acc[BUFFER_SIZE + 2];              //locations, Acc[...], has
      LeftOver[ 3] = Acc[BUFFER_SIZE + 3];              //been generated but are not
      LeftOver[ 4] = Acc[BUFFER_SIZE + 4];              //a part of the current
      LeftOver[ 5] = Acc[BUFFER_SIZE + 5];              //pOut[i], so save this data
      LeftOver[ 6] = Acc[BUFFER_SIZE + 6];              //in the LeftOver[...] buffer
      LeftOver[ 7] = Acc[BUFFER_SIZE + 7];              //and add to next set of
      LeftOver[ 8] = Acc[BUFFER_SIZE + 8];              //input data (next pIn[])
      LeftOver[ 9] = Acc[BUFFER_SIZE + 9];
      LeftOver[10] = Acc[BUFFER_SIZE +10];
      LeftOver[11] = Acc[BUFFER_SIZE +11];
      LeftOver[12] = Acc[BUFFER_SIZE +12];
      LeftOver[13] = Acc[BUFFER_SIZE +13];
      LeftOver[14] = Acc[BUFFER_SIZE +14];
      LeftOver[15] = Acc[BUFFER_SIZE +15];
      LeftOver[16] = Acc[BUFFER_SIZE +16];
      LeftOver[17] = Acc[BUFFER_SIZE +17];
      LeftOver[18] = Acc[BUFFER_SIZE +18];
      LeftOver[19] = Acc[BUFFER_SIZE +19];
      LeftOver[20] = Acc[BUFFER_SIZE +20];
      LeftOver[21] = Acc[BUFFER_SIZE +21];
      LeftOver[22] = Acc[BUFFER_SIZE +22];
      LeftOver[23] = Acc[BUFFER_SIZE +23];
      LeftOver[24] = Acc[BUFFER_SIZE +24];
      LeftOver[25] = Acc[BUFFER_SIZE +25];
      LeftOver[26] = Acc[BUFFER_SIZE +26];
      LeftOver[27] = Acc[BUFFER_SIZE +27];
      LeftOver[28] = Acc[BUFFER_SIZE +28];
      LeftOver[29] = Acc[BUFFER_SIZE +29];
}                                                       //338)(end of "DigitalSig...()" )
//============================== Line 339 ============================
// end of program
```

Figure 4, continued: DigitalSignalProcessing()

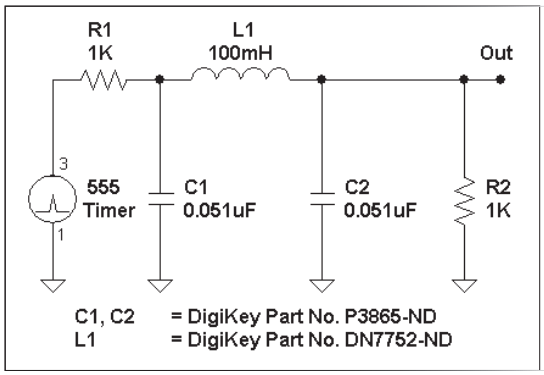


Figure 5: A 3 KHz RLC Lowpass Filter

Similarly, the output from a DSP algorithm is generally another sequence, or train, of binary numbers known as output samples. Just as there is an A/D on the front end of a DSP system, there is a corresponding device at the back end called a D/A (Digital to Analog) converter. After the digital signal processor executes the desired algorithm to transform input samples into output samples, the D/A converter translates the output samples back to an analog signal. It's this analog signal you hear on your PC's speakers. You can learn more about the A/D converter (ADC) and the D/A converter (DAC) in chapter 3, "ADC and DAC", of reference [4].

Convolution-Based Filters Demystified

I can state the secret behind the algorithm for convolution-based DSP filters in one sentence. That is, for any time-invariant linear system, if the system's impulse response is known, the system's output signal can be determined for any input signal by convolving its input with the system's impulse response. For the low pass filter software here, a linear system known as a Windowed-Sinc 3 kHz low pass filter was selected. Then, a sampled version of its impulse response, h[ ], was obtained from ScopeFIR. And finally, software was coded which computer-convolves input samples, whatever they may be, with h[ ] to produce the corresponding, low pass-filtered output samples. What remains, is to understand the key concepts "linear system", "time-invariant", "impulse response", and "convolution".

"Time invariant" means that the system's response to any particular input signal will be the same no matter when it occurs, at the present moment or at any future moment.

A "linear system" is a system that's homogeneous and additive. A system is homogeneous if a change in the amplitude of its input signal results in a proportional change in amplitude of its output signal. In other words, if the amplitude of the input doubles, the amplitude of the output must double, and if the input is cut in half, the output must be cut in half also. Among other things, this means the system ceases to be linear to the extent it "flat tops" its output signal, creating harmonic distortion, such as occurs when you turn up your stereo amplifier too loud. Continuing, a system is additive if its overall response to an input made from two or more individual signals summed together, is identical to, the summation of the system's separate responses to each of these signals individually. Among other things, this means the system ceases to be linear to the extent components of its input signal can interact to create entirely new signals and responses somewhere between its input and output, such as in the case of intermodulation distortion. For another presentation of linear systems, see chapter 5, "Linear Systems", in reference [4].

The "impulse response" concept is usually presented in highly abstract terms. A more down-to-earth approach will be used here. Consider the following experiment. First, construct a 3 kHz RLC low pass filter circuit according to Figure 5. Then, rig up a common 555 timer IC (Radio Shack #276-1723) as an oscillator running at, say, 500 Hz. Next, rig up a second 555 timer to output a 10 volt, 320 us (microsecond) wide pulse. Use the first 555 to trigger the second 555 so it puts out a steady stream of pulses. Now, think of the way a submarine sends out sonar pings to probe its underwater world. So, ping the input of the filter by connecting it to the output of the second 555 timer and observe the filter's output response with an oscilloscope. To determine when the second 555 timer is generating a suitable impulse ping, cut its pulse width in half to 160 us, then in half again to 80 us, and so forth. The second 555 timer will be generating a "virtual impulse" when its pulse width can be cut in half, but the basic shape of the filter's response remains unchanged. Figure 6 shows the impulse response of the 3 kHz low pass filter to a virtual impulse of 10v at 10 us wide.

Next, keeping the width at 10 us, crank up the power supply powering the 555 timers to increase the amplitude of the virtual impulse to 15 volts. Now, the filter's response is the same as for the 10v pulse, except its amplitude is 1.5 times higher. See Figure 7. Note how the amplitude of the response varies in proportion to the amplitude of the impulse, provided the pulse width is kept constant. This strongly implies this circuit is homogeneous.

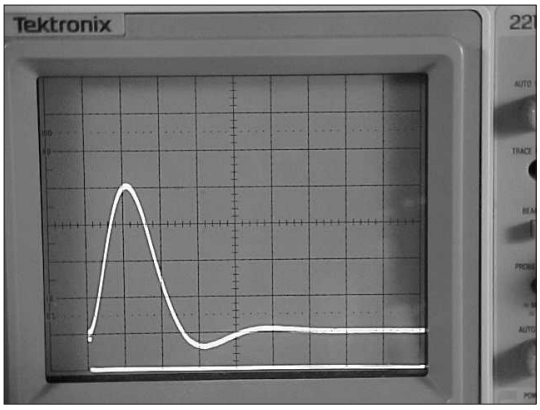


Figure 6: Impulse Response of the 3 KHz RLC Lowpass Filter to a 10v, 10 us Virtual Impulse
Lower Trace, Channel 1: Input Impulse, 10 volts/division
Upper Trace, Channel 2: Impulse Response, 0.05 volts/division
Time base: 100 microseconds/division

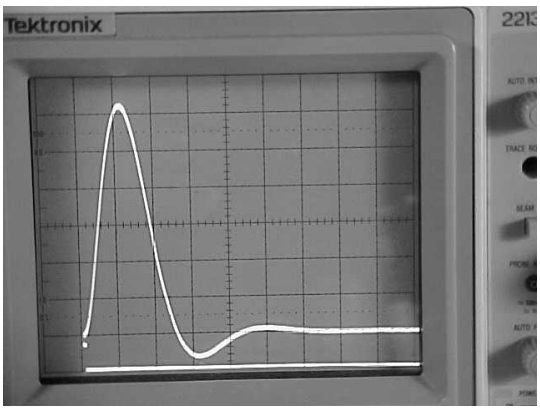


Figure 7: Impulse Response of the 3 KHz RLC Lowpass Filter to a 15v, 10 us Virtual Impulse
Lower Trace, Channel 1: Input Impulse, 20 volts/division
Upper Trace, Channel 2: Impulse Response, 0.05 volts/division
Time base: 100 microseconds/division

Then, use another 555 timer to add a second 10v, 10 us impulse to the original 10v, 10 us impulse. Make the added impulse occur 200 us after the original. Now, ping the filter with this double impulse. See Figure 8. The overall response appears to be same as the the summation of the filter's individual responses to each impulse by itself. In other words, the response appears to be one impulse response, as before, added to another impulse response occurring 200 us later. This strongly implies this circuit is additive. Since the 3 KHz RLC low pass filter appears to be homogeneous and additive, it's a linear system. What we've done is to find, and investigate, the impulse response of this linear system.

Generally, the aforementioned has useful consequences for any signal processing scheme that can be classified as a linear, time-invariant system. First, it implies we can decompose the input signal into a series, or train, of scaled impulses. Next, knowing the system's impulse response, we can individually calculate each scaled impulse response for each of these scaled impulses. And finally, we can align all the scaled impulse responses in time and sum them together to find the overall response of the system.

This is the strategy of the DSP filter algorithm implemented in DigitalSignalProcessing (). First, by the systematic incrementing of index variable "i" in line 271, each successive input sample, pIn[i], is selected one at a time. In other words, the input signal is viewed as a train of scaled impulses. Next, in lines 273 through 303, with the term ... pIn[i] * h[...], the scaled impulse response is calculated for the selected scaled impulse, pIn[i]. Or more exactly, a sampled version of this scaled impulse response is calculated, all 31 samples of it. Then, with the term Acc[i + ...] = Acc[i + ...] + ..., this scaled impulse response is summed, sample by sample, with previous impulse responses already summed together in the accumulator, Acc[ ]. Now, consider the following carefully:

The first input sample occurs at the time-point denoted by i = 0. Its impulse response starts at the same time (i = 0), continues for 30 more time-points, and is summed with the accumulator at locations Acc[0] through Acc[30]. Then, the second input sample occurs at i = 1. Its impulse response starts at the same time (i = 1), continues for 30 more time-points, but it's summed with the accumulator at locations Acc[1] through Acc[31]. First, note how the second impulse response occurs one time unit, or sample interval, later that the first, and in this manner, how the first response overlaps the second. Now, note how this is accounted for by first accessing Acc[0] to Acc[30] for the first impulse response, and then shifting by one time unit within the accumulator to access Acc[1] to Acc[31] for the second impulse response. This one time unit, or sample interval, time shift is repeated over and over for each successive impulse response as it is summed with previous responses. In this way, the current impulse response is properly time-aligned with previous responses as it is being summed with them.

Finally, in line 305, note that Acc[i], for the current i, will never be referenced again as i will soon advance to i + 1, and what's more, the accumulation of impulse response samples in Acc[i] is complete, making Acc[i] now an element in the overall response of the system. But before Acc[i] is outputted, note that Acc[i] may be too large due to the accumulation process. So first, Acc[i] is normalized by dividing it by 32768, and then it's outputted to pOut[i], which assembles the system's overall response.

"Convolution" is implemented on digital computers by process described above. I call this process "computer-convolution" because digital computers don't do real convolution. Real convolution is similar in concept, however, except it deals with continuous, analog signals. But, as we've seen, digital computers choke on analog signals. So, digital signal processors approximate convolution. For another presentation of what convolution is and how it works, read Chapter 5, "Linear Systems", then Chapter 6, "Convolution", and then Chapter 7, "Properties of Convolution", in reference [4].

And finally, because a digital signal processor is a math engine, and mathematics manipulates idealized concepts and abstractions oblivious to the imperfections and limitations of real-world circuit reality, we can perform serious magic with DSP. In a nutshell, this is why DSP is so superior to the signal processing results of analog electronic circuits. For example, note that DSP filter kernels look symmetrical around their largest peak amplitude, whereas real-world impulse responses do not. That is, a real-world impulse response looks something like the right side only of a symmetrical DSP impulse response. This characteristic gives DSP filters a desirable property known as linear phase, something analog electronic filters will never have.

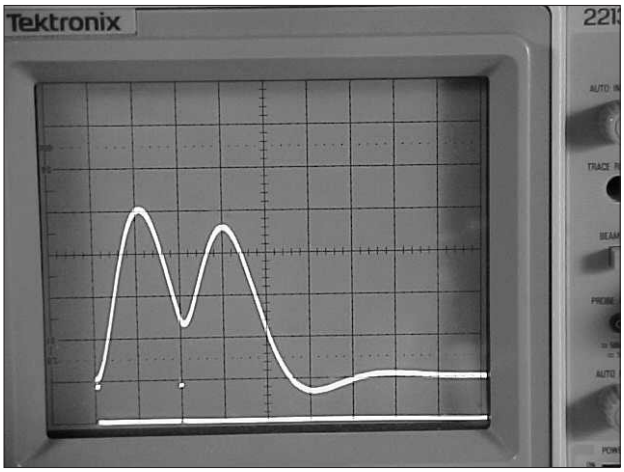


Figure 8: Impulse Response of the 3 KHz RLC Low pass Filter to Two 10v, 10 us Virtual Impulses Spaced 200 us Apart
Lower Trace, Channel 1: Input Impulses, 10 volts/division
Upper Trace, Channel 2: Impulse Response, 0.05 volts/division
Time base: 100 microseconds/division

References

[1] Petzold, Charles (2000), *Code*, Microsoft Press, Redmond, WA, ISBN 0-7356-0505-X, ISBN 0-7356-1131-9 (paperback)

[2] Zhang, Tony, and Southmayd, John (2000), *Sams Teach Yourself C In 24 Hours*, Sams Publishing, Indianapolis, IN, ISBN 0-672-31861-X

[3] Petzold, Charles (1999), *Programming Windows, Fifth Edition*, Microsoft Press, Redmond, WA, ISBN 1-57231-995-X

[4] Smith, Steven W. (1997), *The Scientist and Engineer's Guide To Digital Signal Processing*, California Technical Publishing, P.O. Box 502407, San Diego, CA 92150-2407, "www.DSPguide.com", ISBN 0-9660176-3-3

Field Ops Update - December 2007

Gould Smith, WA4SXM, wa4sxm@amsat.org
VP, User Services

I want to thank the 180 members of the AMSAT Field Operations Team for volunteering their time and talents for AMSAT. I am sure that the many people you have informed and helped over the last year appreciate your efforts also.

New Area Coordinators

I am pleased to announce three new Area Coordinators since the last report. Clint Bradford, K6LCS, Maurice-Andre Vigneault, VE3VIG, and Ian MacFarquhar, VE9IM. If you are interested in giving back to AMSAT by representing AMSAT at hamfests, club meetings, schools and one on one, then send me an email at wa4sxm@amsat.org.

AMSAT Area Coordinators:

- Represent AMSAT at hamfests
- Encourage satellite activities by doing demonstrations
- Serve as satellite 'Elmers'
- Make presentations at club meetings and hamfests
- Conduct local and regional nets
- Answer satellite questions via email or telephone
- Provide articles for *The AMSAT Journal*
- Provide technical review for articles and the Web site
- Involve schools with satellite projects and demonstrations

Field Ops Breakfast

The Field Ops Breakfast Sunday morning during the 2007 Symposium in Pittsburgh was well attended. Twenty seven percent of the Symposium attendees were there to enjoy breakfast, fellowship and discuss better ways to serve the AMSAT members. I gave the group a report of the year's activities and goals for 2008. AMSAT had a presence at 47 hamfests during 2007, and we are looking to increase that number in 2008.

I encourage all AMSAT members to attend all ARISS contacts within range. This is an extremely rewarding experience and you have a great deal of information to offer the students. The AMSAT Events Calendar on the AMSAT Web site will list the upcoming ARISS events. Sometimes there is only a few days notice, so check often.

Another great set of events to attend are the VHF/UHF conferences and the digital conferences around the US. We have a great deal in common with these groups and I know you will learn a great deal and make new friends.

- Eastern VHF/UHF Conference http://www.newsvhf.com/
- Southeastern VHF Society http://www.svhs.org 25-26 April 2008, Orlando, FL
- Central States VHF Society http://www.csvhfs.org 24-27 July 2008 Wichita, KS
- Pacific Northwest VHF Society http://www.pnwvhfs.org TBD
- Digital Communications Conference http://www.tapr.org/dcc.html TBD
- Microwave Update TBD

2007 Field Operations Awards

Keith Pugh, W5IU

In recognition of your multiple contributions to the AMSAT Field Ops team. Your efforts as net control for the 20M AMSAT net and for multiple ham club talks and demonstrations during the year continue to showcase AMSAT. In addition your multi-day operations at Dayton and HAMCOM in Dallas highlight your invaluable contributions to the organization and to Amateur Radio operators. Your willingness to organize three days of satellite demonstrations at Dayton at the last minute and do it so well that your demonstrations received great applause is a testament to your ability and dedication. Your service as an ARISS Mentor has been extremely valuable. The well-chosen words used in your CQ VHF Satellite column continue to keep AMSAT activities highlighted to all its readers.

Dee Interdonato, NB2F

You have represented AMSAT at 6 hamfests, given 2 talks and a satellite demonstration this year. You continue to prove yourself as a model Area Coordinator. You want the best for AMSAT and the Field Ops team and work to get that accomplished. In addition you co-edit the ANS every month and have been a valuable resource at Dayton for many years.

Patrick Stoddard, WD9EWK

In recognition of your many contributions to the AMSAT Field Ops team. Your leadership at the AMSAT booths at hamfests in the Phoenix area, performing multiple satellite demonstrations and satellite talks have all greatly enhanced the satellite operations in southern Arizona. You have also proven to be a valuable member of the AO-51 Operations team.

Robert Davies, KI4HXT

Your enthusiasm and vigor in representing AMSAT at practically every south and central Florida hamfest is above and beyond the call of duty for an Area Coordinator. Your willingness to guide and mentor newcomers at hamfests, at home, and wherever needed is much appreciated, as is your continued participation as a founding member of the Florida AMSAT net heard over most of Florida. Thank you!

David Jordan, AA4KN

Thank you for your continued support of two of the largest hamfests in Florida, your work with the local CubeSat teams, and your continued participation as a founding member of the Florida AMSAT net heard over most of Florida.

Erich Eichmann, DK1TB

This award is presented in recognition of your donation of SatPC32, the preeminent amateur satellite tracking software, to AMSAT and for your continued support and enhancements to this valuable tool.

Ed Collins, N8NUY

In recognition of your many years of service to AMSAT as the Dayton Hamvention representative and especially for your outstanding work to make the 2007 AMSAT/TAPR banquet at the Air Force Museum a huge success.

Mike Young, WB8CXO

In recognition of your many days of work on the LVB Tracker box in getting it ready and delivering it as a product. Your creative demonstration unit at Dayton proved to be invaluable in showcasing this product. Your willingness to volunteer to build and test these units is in the true spirit on an AMSAT volunteer.

Lee McLamb, KU4OS

In recognition of your efforts as co-editor providing the AMSAT community with the weekly AMSAT News Service (ANS). This service keeps the amateur satellite community informed and abreast of the important events relevant to satellite communications.

JoAnne Maenpaa, K9JKM

In recognition of your efforts as co-editor

to provide the AMSAT community with the weekly AMSAT News Service This service keeps the amateur satellite community informed and abreast of the important events relevant to satellite communications. Your help during the Dayton Hamvention and work with the AMSAT Web site front page news stories have been invaluable to the AMSAT community.

Ed Long, WA4SWJ

In recognition of your Herculean effort in getting *The AMSAT Journal* edited, assembled, laid out and to the printer six times a year. Thank you for an outstanding job and publication that the membership looks forward to receiving. *(Thanks Gould and I want thank Bill Hook, W3QBC, for his outstanding assistance. - Ed.)*

Eric Christensen W4OTN

Thank you for your continued management of emails arriving via Web site submission, the maintenance of the satellite status page on the Web site, and supporting hamfests in your area. Your work is important and appreciated.

James French, W8ISS

Thank you for your weekly compilation and publication of the Weekly Satellite Report. Your dedication has made WSR a reliable and constant source of information on the AMSAT fleet.

Dieter Schliemann, KX4Y

In recognition of your many days of volunteer service to AMSAT at the AMSAT Booth in Dayton and at the ARRL National Convention in Huntsville. In addition, your continuing support of the ARISS project by providing worldwide coverage of ARISS contacts via EchoLink and IRLP has proven to be an invaluable service and inspiration to many.

Bruce Paige, KK5DO

In recognition of your many contributions to AMSAT. These include the weekly satellite award notices and your well managed amateur satellite contests. Your Houston AMSAT Net provides a worldwide forum and news source for all amateur satellite operators. The Houston AMSAT Net Web site is a useful complement to the AMSAT Web site. In addition, your help with the AMSAT Store is much appreciated.

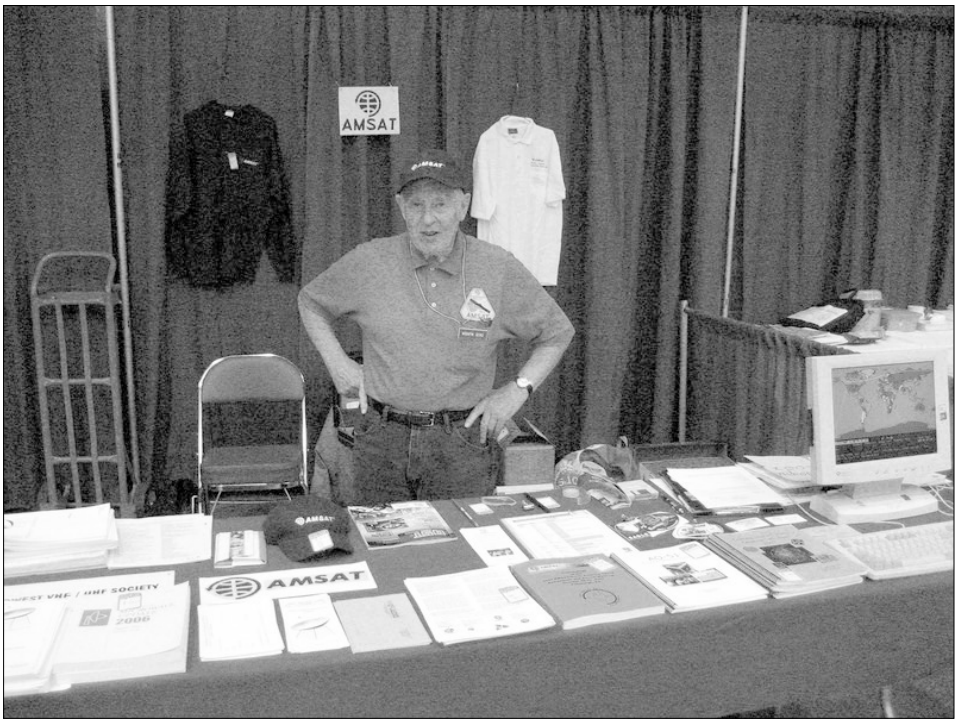
Larry Brown, W7LB

Presented in recognition of your continued service to AMSAT. Your efforts as a Regional Coordinator have been very helpful as well as your representation at multiple hamfests, making presentations and doing satellite demonstrations. Your extra effort in helping the Pueblo High School setup a satellite station and your support during their ARISS contact is much appreciated.

AMSAT at the Ft. Wayne, IN Hamfest

Jeff Davis, KE9V, ke9v@amsat.org

I had a good time at the Ft Wayne Hamfest recently. I caught Gerd, WB8IFM, manning the AMSAT booth and speaking at the AMSAT forum.



WB8IFM mans the AMSAT booth at Ft. Wayne.

WB8IFM also presents to the crowd at Ft. Wayne.

International Amateur Radio Union
Amateur Radio Satellite Forum 2007

This forum meets annually to discuss issues that are of relevance to the Amateur Radio satellite fraternity and informs the IARU Satellite Advisor on items that should be brought to the attention of the IARU Administrative Council. The forum is hosted in alternate years in the USA as part of the AMSAT NA Space Symposium and in the UK as part of the AMSAT UK Satellite Colloquium. The 2007 Forum was held in Pittsburgh, USA on 28 October 2007 at 09:00.

Forum Report

The IARU Satellite Advisor, Hans van de Groenendaal, ZS6AKV, presented a brief report highlighting the work of the Satellite Frequency Advisory Panel over the past year. He thanked the panel members for their work during the past year. He highlighted the following points:

1. The number of CubeSats planned each year has greatly increased the load on the panel. He urged local AMSAT groups and national societies to become more involved with the university groups building satellites and share with them the Amateur Radio culture. It is important for builders of CubeSats to have a good understanding of how Amateur Radio functions. This is important for the ultimate success of their mission and seamless integration into Amateur Radio without causing interference to terrestrial and satellite Amateur Radio operation.
2. Often at the time of the coordination request and recommendation from the Advisory Panel the launch details and what other CubeSats are on the same launch are not available. It is recommended that CubeSat builders continually review the coordination request and frequency recommendations and keep the panel informed of developments to avoid last minute frequency changes or conflicts.
3. The Amateur Radio frequency spectrum is a scarce resource and needs to be managed carefully, taking both terrestrial and satellite applications into consideration to arrive at the best utilization of the spectrum. It is therefore impossible to allocate a unique frequency to a CubeSat.

Discussion on Frequency Wish List

The IARU maintains a frequency wish list that is reviewed and updated annually. For many years the satellite fraternity has not provided any major input. The changing situation and the quest for higher frequencies have necessitated that more proactive action be taken. Graham Shirville tabled a proposal that had been developed by the RSGB in collaboration with AMSAT-UK.

After extensive discussion it was agreed to put forward the following Plan for consideration (Table 1). AMSAT groups in the international list will be canvassed for comment and input before the list will be finalized and submitted to the IARU AC. It will also be necessary to develop a set of justifications on why these additional or revised allocations are important for future development.

Table 1: Proposed New Satellite Band Plan

Band	
50 - 51 MHz	Seek new harmonized Amateur Satellite Service E-S and S-E allocation for communication and propagation research complementing existing Amateur Service requirements.
438 - 440 MHz	Extension to existing allocation E-S and S-E
1240 - 1250 MHz	E-S and S-E
2300 - 2330 MHz	E-S and S-E
2390 - 2400 MHz	E-S and S-E Currently primary in USA 2390 - 2395 MHz and shared Primary 2395 - 2400 MHz
3400 - 3410 MHz	E-S and S-E Already available in Regions 2 and 3This is an urgent request as current lack of allocation in Region 1 is limiting the use of this band
5650 - 5670 MHz	E -S and S-E
10 GHz	Satellite Service requires 10 MHz allocation 10360 - 10400 MHz and work toward 10450 - 10460 MHz as Primary

E-S is "Earth to Space"

S-E is "Space to Earth"

Two Meter Band Plan

A proposal "To permit satellites operating in the Amateur Satellite Service which incorporate linear transponders for CW and SSB activities to use, on a non exclusive basis, the section of the 2 meter band 144.310 –144.370 MHz for downlink (satellite to ground) mode only" had been rejected at the IARU Region 1 interim meeting in Vienna earlier this year.

Another proposal now on the table for the IARU Region 1 Triennial Meeting in November 2008 reads as follows:

"To permit satellites, operating in the Amateur Satellite Service, which incorporate "linear" transponders, which are generally used for narrow band, non-channelized signals, to use, on a **non-exclusive basis**, the section of the 2 meter band 144.005 –144.045 MHz for downlink (satellite to ground) mode only, by amending the band plans in each IARU Region."

AMSAT NA agreed in principle but would like to take the proposal on advisement. Rick Hambly offered to provide feedback in a month. Bill Tynan will consult with the US EME group and report back to Rick Hambly.

145.800 – 146.000 MHz Downlink only Recommendation

The presence of interfering non-amateur signals in the 145.80-146.00 MHz part of this band in many parts of the world, is well documented. To prevent the retransmission of interfering terrestrial signals, satellites in the Amateur Satellite Service that plan to use the 2 meter amateur band for communication transponders are encouraged to use this band for downlink (satellite to ground) modes only, regardless of modulation type.

Increased Congestion

It was further recommended that builders of CubeSats be discouraged from using the 2 meter band to prevent the sames few frequencies in the limited available spectrum from being allocated over and over, which is creating a potential for interference, particularly if the satellites are designated for the same launch. It was agreed and the IARU Satellite Advisor will prepare documentation to promote the concept. All

The meeting ended at 10:45 AM.

AMSAT-UK and ESA Co-operation on GENSO

by Trevor, M5AKA

In recent years university students around the world have built a number of small educational satellites – CubeSats that have been launched into low earth orbit. Often there is just one dedicated ground station for each CubeSat that may only be able to communicate with the satellite for less than an hour each day. This has made it difficult to make full use of the spacecraft and maximise the educational benefits.

However, this situation is about to change, thanks to the initiative of the International Space Education Board to establish a global ground station network for educational users. The Global Educational Ground Station Network (GENSO) will be a global infrastructure for future educational satellite projects.

The 9 objectives of GENSO are:

1. To provide unparalleled near-global levels of access to educational spacecraft in orbit
2. To allow remote access for operators to real-time mission data, even in cases when their local ground station is experiencing technical difficulties
3. To provide remote control of all participating ground stations
4. To optimize uplink fidelity by calculation of real-time link budgets and uplink station selection
5. To perform downlink error-correction by comparing multiple data streams
6. To define and implement a global standard for educational ground segment software

continued on page 25 ...

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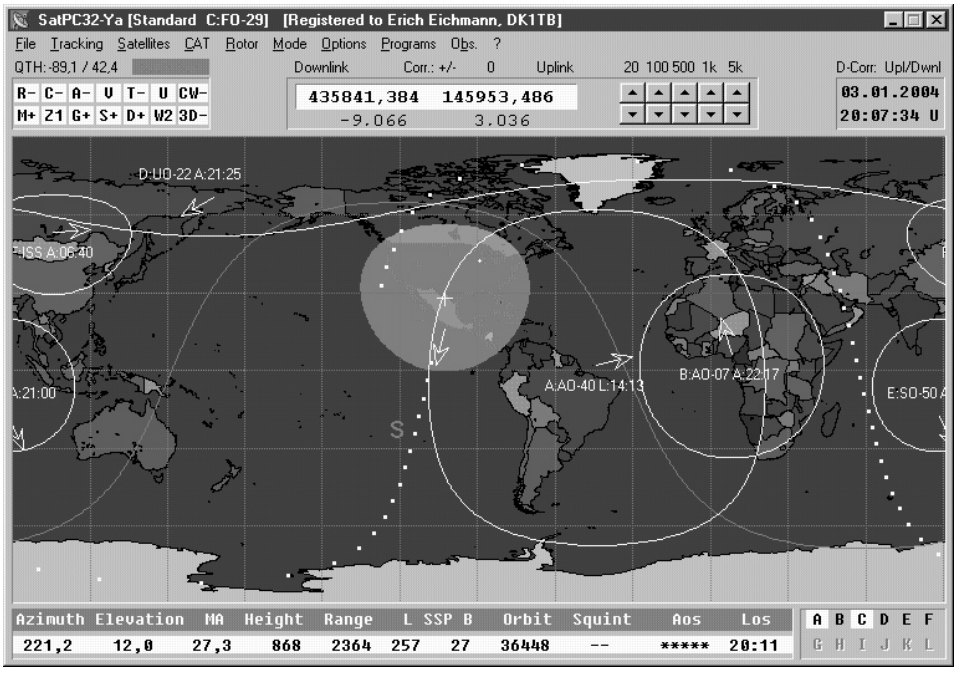

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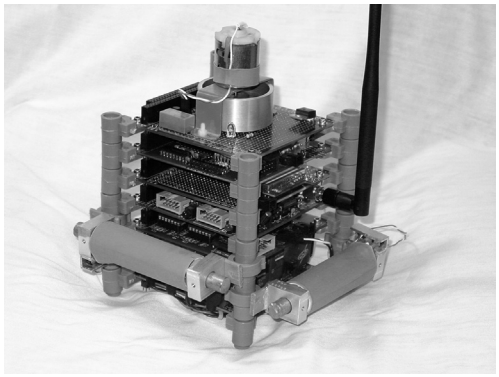

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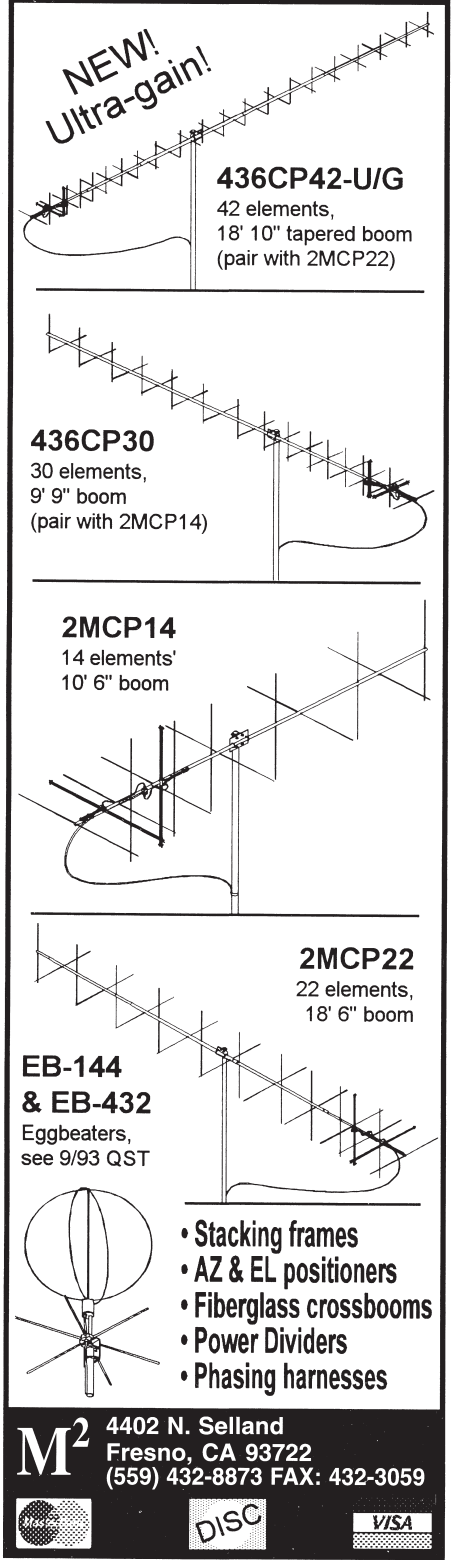

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DISC VISA

The Orbital Classroom, Column #11
To the Moon, Alice!

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AMSAT Director of Education

The Orbital Classroom

Want to go to the Moon? If you're of the Apollo Generation (as, in fact, are most AMSAT members), having come of age in the shadow of "One Small Step", you probably hesitated less than an eye-blink before answering in the affirmative. After all, if we can put a man on the Moon, we reason in an expression of frustration with current NASA priorities, why can't we put a man on the Moon?

The next best thing would be to orbit the Moon, and if we can do so with Amateur Radio equipment on board, so much the better. Over the next few years, we just might have not one, but two chances to do so. At the August 2007 Small Satellite Conference at Utah State University, a couple of interesting opportunities were discussed.

ESMO, the European Student Moon Orbiter, is an ESA (European Space Agency) initiative to deploy a spacecraft carrying a student-designed science package into Lunar orbit by 2011. This third mission of the Student Space Education and Technology Initiative (SSETI), has the following four broad objectives:

- Education: prepare students for careers in future projects of the European space exploration and space science programs by providing valuable hands-on experience on a relevant & demanding project.
- Outreach: acquire images of the Moon and transmit them back to Earth for public relations and education outreach purposes.
- Science: perform new scientific measurements relevant to lunar science & the future human exploration of the Moon, in complement with past, present and future lunar missions.
- Engineering: provide flight demonstration of innovative space technologies developed under university research activities.

As proposed, the ESMO payload would be inserted into Geostationary Transfer Orbit (GTO), on either an Arianne V or a Soyuz launch vehicle. According to the ESMO Web site, "from GTO, the 200 kg spacecraft would use its on-board propulsion system for lunar transfer, lunar orbit insertion and orbit transfer to its final low altitude polar orbit around the Moon. A 10 kg miniaturized suite of scientific instruments (also to be provided by student teams) would perform measurements during the lunar transfer and lunar orbit phases over the period of a few months, according to highly focused science objectives. The core payload would be a high-resolution narrow angle CCD camera for optical imaging of lunar surface characteristics. Optional payload items being considered include a LIDAR, an IR hyperspectral imager, a mini sub-surface sounding radar for polar ice detection, and a CubeSat subsatellite for precision gravity field mapping via accurate ranging of the subsatellite from the main spacecraft." As would be expected, several European AMSAT organizations (including AMSAT-UK and AMSAT-DL) are lending support for this exciting mission opportunity.

Not to be outdone, in the US, the NASA Office of Education has proposed an American Student Moon Orbiter (ASMO), to be both competitive and cooperative with the European mission. ASMO, according to NASA, "offers to next generation explorers unique opportunities for integral involvement in the U.S. space exploration program. The ASMO project will be carried out as a diverse nationwide higher education initiative by which American university students and their faculty advisors will design, build, register, launch and own the ASMO small spacecraft and its payload."

Why would NASA risk turning over a major component of its lunar research to a group of students? During the years of the Apollo program, the average age of NASA's workforce was 26. Today, NASA employees average 47 years of age, with 25% eligible for retirement within the next five years. By bringing bright young technologists on board now, it is reasoned, NASA will have a shot at replenishing itself around the time those retirements kick in.

Both ESMO and ASMO will conduct scientific experiments in Lunar orbit, and very likely will employ Amateur Radio for telemetry, tracking and control of their respective scientific missions. According to the NASA Web site, "The student-built ASMO craft could be launched to orbit the Earth's Moon in 2011 in tandem with a spacecraft to be developed by European students under a companion European Student Moon Orbiter (ESMO) program. Through coordination with ESA's ESMO program and possible spacecraft interoperability, valuable opportunities for international scientific and technical collaboration could be offered. Conceived to accommodate a 10kg payload in a highly elliptical two year lunar orbit, there are numerous options for ASMO to serve as a valuable data gathering mission and technology demonstration that will enhance understanding of the lunar environment and advance the small satellite field."

Your humble Director of Education had the opportunity, at the aforementioned Small Satellite Conference, to meet with some of the student teams that are bidding on pieces of the ESMO and ASMO missions. These incredibly bright young men and women remind me a little of my fellow AMSAT members and, yes, myself, more decades ago than I care to admit. They are mostly Aerospace Engineering students at some top colleges and universities, with their heads in the clouds in true Space Cadet fashion. Some are even licensed radio amateurs, having cut their technological teeth on CubeSat projects. However, in the areas of space communications and control, they appear to have only a limited understanding of the problems they are going to face, and little experience to apply to their solution. Here's where we come in.

To date, neither ESA nor NASA has officially requested AMSAT involvement in the ESMO or ASMO missions, respectively. However, given the likelihood of employing Amateur Radio frequencies, the expertise available within our ranks, and the educational focus of both missions, it stands to reason that we are in a position to offer technical assistance in the areas of frequency selection, modulation and data format tradeoff studies, communications link analysis, spacecraft comm. system design, ground station design and operation, and training support for the ASMO and ESMO ground crews (who, we certainly hope, will all become licensed radio amateurs, some time prior to launch).

One thing that every amateur moonbouncer knows is that it's a long way to the Moon,

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The Orbital Classroom continued ...

and until Congress sees fit to repeal the Inverse Square Law, free space isotropic path loss is going to dominate communnications link design for these challenging missions. Thus, to achieve any reasonable data rate over lunar distances, we're going to have to put our hands on some pretty big dishes to ensure mission success. The challenges of earth station design for a lunar mission will be explored in the next Orbital Classroom column.

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AO-51 to Enter No Eclipse Period

Gould Smith, WA4SXM, wa4sxm@amsat.org
AO-51 Command Station

AO-51 will enter a no eclipse period the first week of January 2008 and be in this condition until the first week of April 2008. The satellite will warm up as it will not have a chance to cool during eclipse. We plan on running the S-band transmitter quite a bit during this period, as it is the most efficient transmitter. We also plan to run a U-band transmitter to help dissipate heat.

Now is the time to get your S-band antenna and downlink system operational, as this should be the primary mode for the next few months. As you can see in Figure 1, we will also have a longer no eclipse period later in 2008. This will run from late August 2008 through April 2009.

This is an excellent opportunity to do some S-band experimentation. I hope to see a number of articles on creative methods people come up with to do portable V/S operation. It doesn't take much of an antenna to receive 2.4 GHz from AO-51, if you have an amplifier in the downconverter. Also looking for some easy mods to the popular K5GNA downconverter to run on something other than the 18-24V sent up the coax by the wall wart.

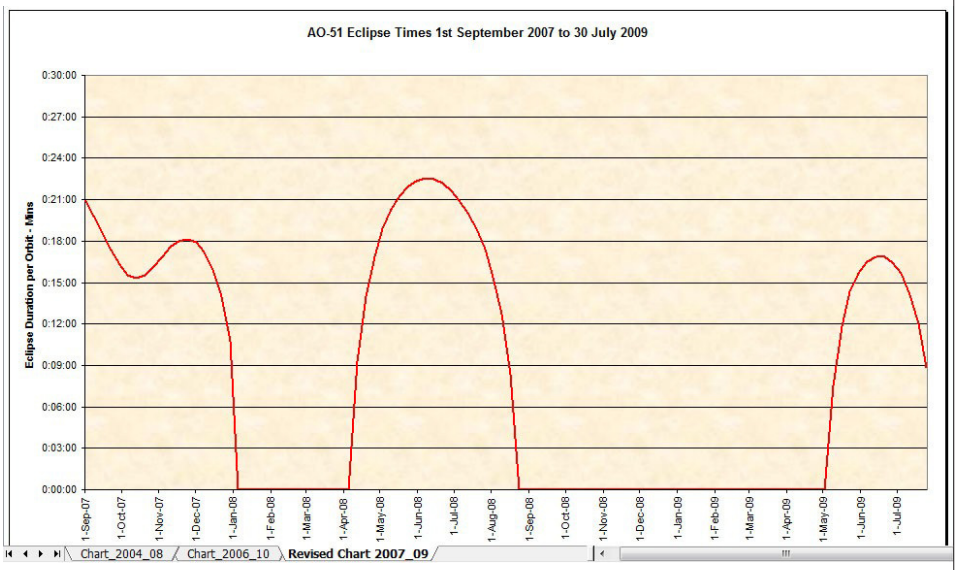
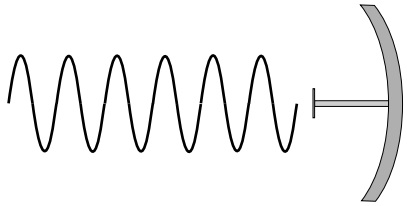


Figure 1. AO-51 eclipse periods 9/07 to 8/09 (from Colin, VK5HI using W4SM program).

A day the children of Arnold Palmer Hospital will never forget. [photo by David Jordan]



First ARISS Contact with a Hospital

David H. Jordan, AA4KN, aa4kn@amsat.org
AMSAT Area Coordinator, Central Florida

On July 17, 2007, I had the privilege of attending a very special event. It was an ARISS contact at the Arnold Palmer Hospital for Children in Orlando, Florida. Eleven of their patients had been chosen to participate, asking questions of ISS astronaut, Clayton Anderson, as he passed over the western U.S.

This contact had originally been the idea of John Rothert, KC4IYO. He applied for the contact in August of 2006. Unfortunately, John became ill shortly afterward and members of the Lake Monroe Amateur Radio Society in Deltona, Florida continued working with the hospital to make this event a reality for the children.

On site the day of the contact and in charge of the setup were Mike Welch, KF4HFC, and Bob Pollack, KF4IMF, of the Lake Monroe club. Representing AMSAT were Lou McFadin, W5DID, and myself. The contact was made through a telebridge connection with W6SRJ at the Santa Rosa Junior College in Santa Rosa, California. Station operator was Bill Hillendahl, KH6GJV, with support from Don Dalby, KE6UAY. The contact began around 14:28 EDT and ran about 9 minutes during which the kids asked a record, 33 questions. Afterward, excitement filled the room as the children were interviewed individually by four local television stations and an AM radio news crew.

The day of the contact, John Rothert was too ill to attend and a few days later, passed away after a year long battle with leukemia. John's quest was always to share ham radio with others and through friends, his dream of this ARISS contact was realized. He will truly be missed.

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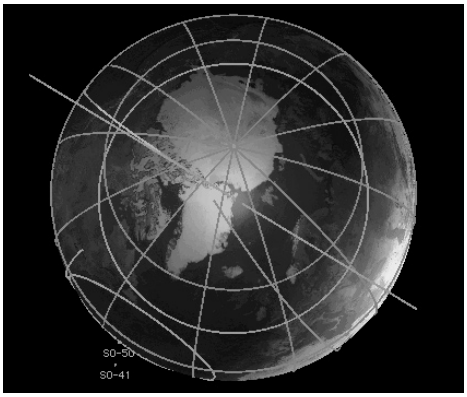

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News from the ZEL – A P3E Update

Gould Smith, WA4SXM, wa4sxm@amsat.org
with information from Hartmut Päsler, DL1YDD

During the 2007 AMSAT Symposium and board meeting, I was able to hear Harmut Päsler, DL1YDD, AMSAT-DL VP update us on the ZEL and P3E. I have heard the P3E (Phase 3 Express) presentations at Dayton and the AMSAT Symposium over the last few years, but never felt I new much about what was going on with the program. In talking with many members at hamfests, I have understood that others felt the same way. I talked with Hartmut at Symposium about wanting to be able to inform our membership about the P3E build. He agreed and has been very helpful in providing information.

An integral part of building a satellite is having an adequate place in which to build it.

The ZEL (Zentrale Entwicklungslabor für Elektronik) is the laboratory at the Phillips (Marburg) University that has been used by Dr. Karl Meinzer, DJ4ZC, and the university for the last 40 years, many of those years for satellite development. The university, AMSAT-DL and other international AMSAT organizations have been able to use the ZEL over the years for satellite construction; AO-13 was built here and many other satellites were designed here. Following the forced retirement of Dr. Meinzer in 2006, the University had decided to close the ZEL at the end of 2007. After some negotiations, AMSAT-DL will be able to rent about half of the lab for 2008 to complete the P3E satellite. Most of the effort by the AMSAT-DL team the last two months has been in clearing the ZEL and moving into their new area. After the first of the year work on the satellite will resume.

Following a request by AMSAT-DL at the 2007 AMSAT Symposium, the BoD voted to donate money to AMSAT-DL to support the completion of P3E during 2008. AMSAT-UK donated a proportional amount, for a total of €25,000. AMSAT paid rent on the ZEL for 2006 and 2007.

In preparing this article it dawned upon me that I didn't understand the full extent of the updates, because I didn't understand the satellite. As with most projects, the more you get into them the larger they become. So, in addition to a quick update, I will go into the basic components of P3E and then talk about the progress of these sections individually. This will be a series of articles that will also serve as a good platform to highlight the ongoing progress during the year.

Quick Update

- Propellant tank qualified and integrated
- Batteries (main and aux) qualified and ready for integration
- VHF/UHF/SHF antennas ready for integration
- Microwave antennas complete
- Sun and earth sensors integrated
- Solar generators (cells) ready for integration
- Magnetorquers integrated
- Wiring harness integrated
- Coax cables ready for integration
- CanDo modules tested and ready for distribution to the module builders
- Clamp band ready for integration
- Helium bottle qualified and ready for integration
- Misc. "small items" (in sum important) integrated
- All mechanical work completed
- IHU-3 not ready
- U/V, STELLA, SDX delayed, but still on track
- LS
  - L-front end - OK, tweaked for minimum Galileo interference
  - Command detector - OK
  - S-TX – work in progress
  - HELAPS – tests necessary

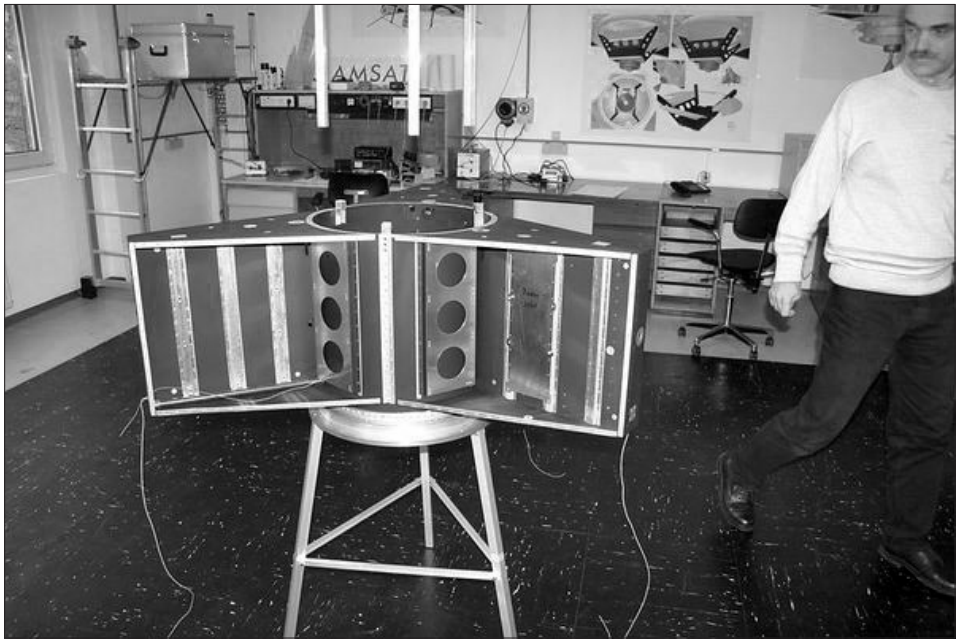


Figure 1: 2005 photo of P3E structure and Hartmut in the ZEL by Bob, N4HY.

Wiring

The wiring on previous four Phase 3 satellites has been quite involved. To simplify this problem the P3E team selected to use the CAN bus to move data around the satellite using far less point-to-point wiring. The spaceframe is complete and the intricate wiring harness is installed throughout the spacecraft. The power cables and the data (CAN bus) cables make up this wiring harness. The coaxial cables are added last. Once the extensively labeled wiring is installed, the components bolt to the superstructure and connect to the wiring harness. You can see in the photographs that the wiring harness with connectors is in place ready to connect to the modules.

On the right end of the photograph in Figure 3 is a DB-9 connector (middle) that connects one of the six solar cells panels, which will cover this part of the arm. Notice the nutation damper rod (the curved piece of pipe on the right hand side in the photograph. The nutation damper is used to convert mechanical energy (caused by the nutation of the satellite) into heat. If you follow the harness from the DB9 solar connector down, you see a big DB50 connector that will connect the BCR. The wiring harness to the bottom center disappears into the central cylindrical section where the motor

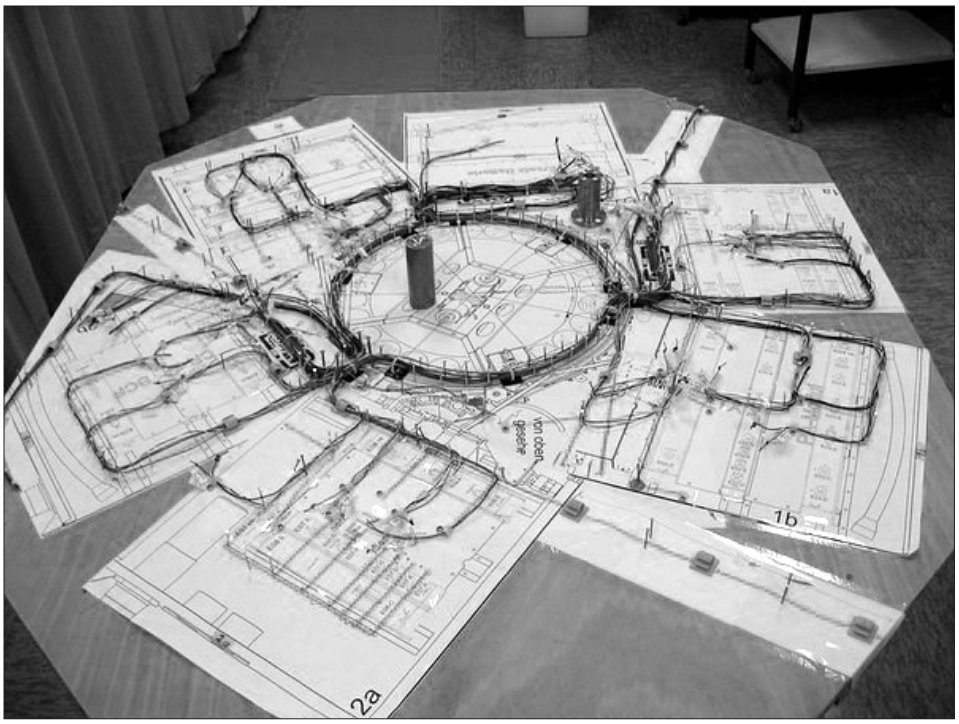


Figure 2: P3E wiring harness.

and tanks are located. The white rectangular features are cardboard printouts showing the connector numbers and descriptions. The orange tags are temporarily placed there by Horst Wagner, DB2ZB, who built the wiring harness to identify each of the plugs.

Figure 4 shows the care and workmanship Horst used in wrapping the wax cord to bind the harness. The connector shown is a power and CAN bus distribution strip. The EB label shows an Engineering Beacon connection.

Figure 11 is a drawing of the two wings of the P3E structure shown in the photograph. The location of the IHU, LIU, Helium tank, K-Band transmitter and BCR modules are shown. This drawing is a little dated; the RUDAK is no longer part of the satellite. A second BCR unit now occupies this module attached to the BCR-1 unit

The nutation damper on the right has a temperature sensor attached that is used to sense the temperature. The amount of temperature change in the rod can be used to determine the nutation of the satellite, the more nutation the more heat. Figure 6 shows the PCB that holds a resistor that needs to be near the temperature sensor. The PCB is small, just 7 mm x 25 mm. The wires go via the wiring harness to the SEU (Sensor Electronic Unit).

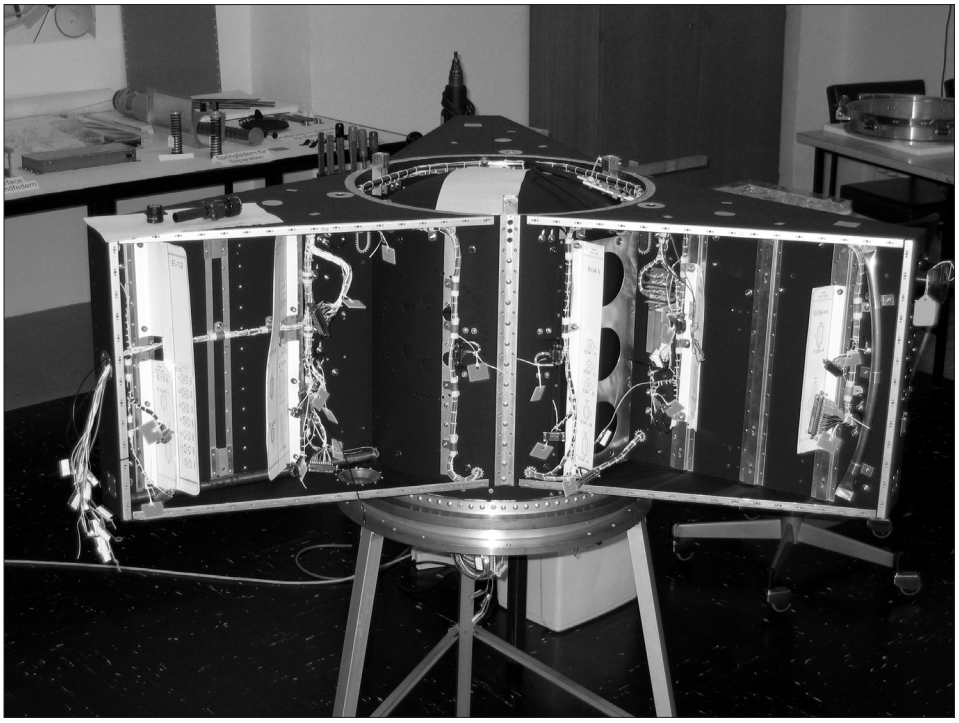


Figure 3: 2007 photograph of P3E wings in the ZEL.

The left-hand wing of Figure 3 is shown in more detail in Figure 6.

This section houses the IHU/LIU (Integrated Housekeeping Unit/Liquid Ignition Unit), helium bottle and batteries. Notice the depression in the lower right-hand portion of the wing. This cradles the rounded bottom of the helium gas container used to pressurize the propellant system. The large 50-pin connector above the depression connects to the IHU. The cables on the outer end of the wing contain a DB-9 connector that goes to the solar cells and a larger connector that attaches to the LIU. The cables coming out of the end cap go to a "Safe/Arm Plug" (Figure 7). This plug serves two purposes:

1) To keep the motor, control, propulsion and pyro bolts inactive.
2) Control and data lines that carry information to the launcher for security checks. This plug is pulled at the last minute.

The two horizontal copper coils at the bottom of the wing are part of the magnetorquer system that interacts with the earth's magnetic field to achieve attitude control when in orbit.

These are RF and IF cables (Figure 8). They are made of thin Teflon coax cable with crimped SMA connectors at the ends. The small labels indicate the end points. The coax cables are not integrated into the wiring harness, they go more or less directly from source to destination. Note the length. Some of them are easily 2 meters long.

The "Chinese hat" at upper right is a cover that fits on top of the tank (Figure 8).

In the box below the table the solar generators are stored. The labeling is "Vorsicht Glas" which is "Beware! Glass".

In the center you see the propellant tank (Figure 9) after testing and qualification. Notice the ubiquitous wiring harness going around the circular aluminum central cylinder to another arm. The "Chinese hat" in Figure 8 goes on top of the propellant tank.

CAN-DO

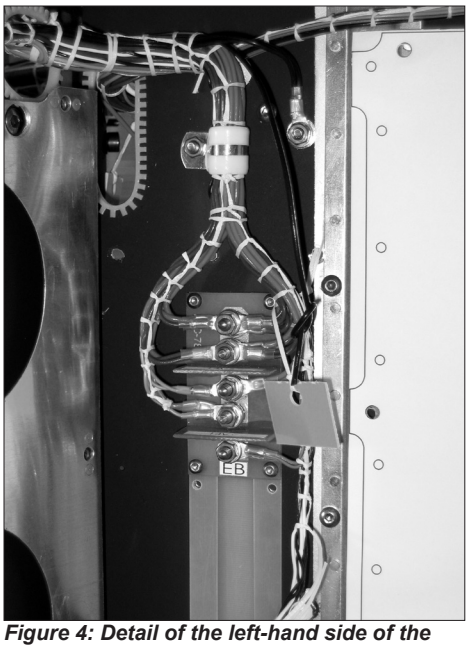


Figure 4: Detail of the left-hand side of the right wing in Figure 3.

Figure 5: Nutation rod temperature sensor.

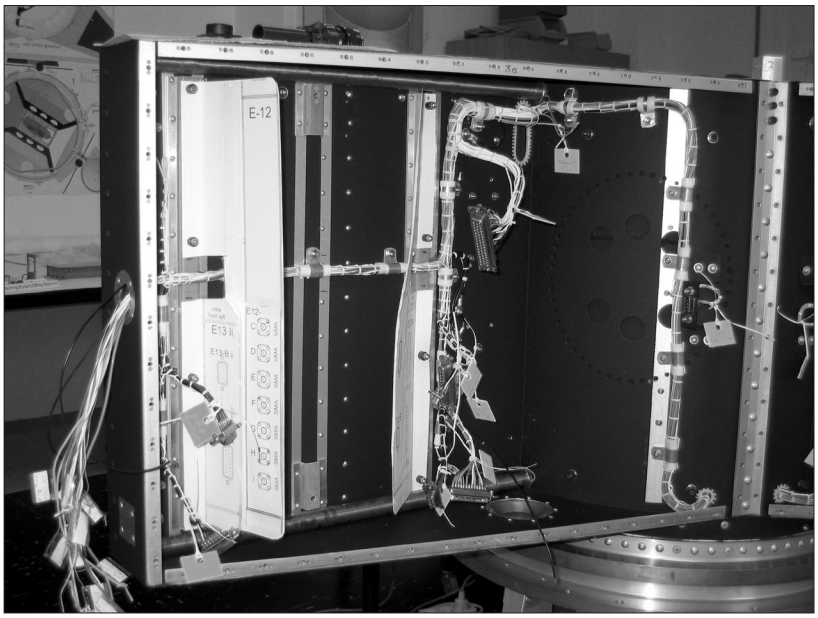


Figure 6: Close up of the left-hand wing of Figure 3.

The CAN-DO widget uses the CAN bus protocol to send data around the spacecraft on a simple bus. A CAN bus is used by most automobiles to transfer data, so it is widely accepted and rugged. Figure 12 shows the new CAN-DO widgets with the tantalum radiation shield chips wrapped in Kapton tape. One Can-Module needs 10 chips in different and really very small sizes - this is a total of 200 to prepare for 20 sets. These are made in Germany by AMSAT-DL. Their cutting machine is not suitable for this precise work; so they have to do it in another lab of the university. Then the plates have to be polished and wrapped in Kapton tape. Although this is tedious work, it has to be done very carefully and nobody likes to do that. This is just one example of the large amount of work needed (but seldom known) on system components to build a satellite.

Building a Satellite

The basic steps in building a satellite are:

- System design
- Orbit determination
- Power generation and usage
- Spaceframe design
- Module and parts specification
- Interface specification
- Prototype build and test
- Interface build
- Re-design
- Engineering build and test
- System testing
- Space qualification (thermal, vacuum and shake test)

P3E Systems

To understand what we are looking at it is important to understand the underlying structure and nomenclature of the modules. We will cover each of these systems over the next few months:

- Wiring Harness
- CAN-DO system
- Fuel tank
- Magnetorquer system
- Solar Arrays 1-6
- Power Splitters
- Diplexers
- 220 N motor
- Propulsion structure
- Release system
- Attachment system

Additional Information

See the following Web links for additional photographs and other information about P3E.

http://n4hy.smugmug.com/gallery/383989/#15309866 for 2005 N4HY photos.

http://www.amsat-dl.org/p3e/ for P3E documents and photographs.

http://www.amsat-dl.org/pic/gallery2/main.php?g2_intemid=323

Photos continue next page ...

Figure 7: Harmut Päsler holding the Safe/Arm Plug.

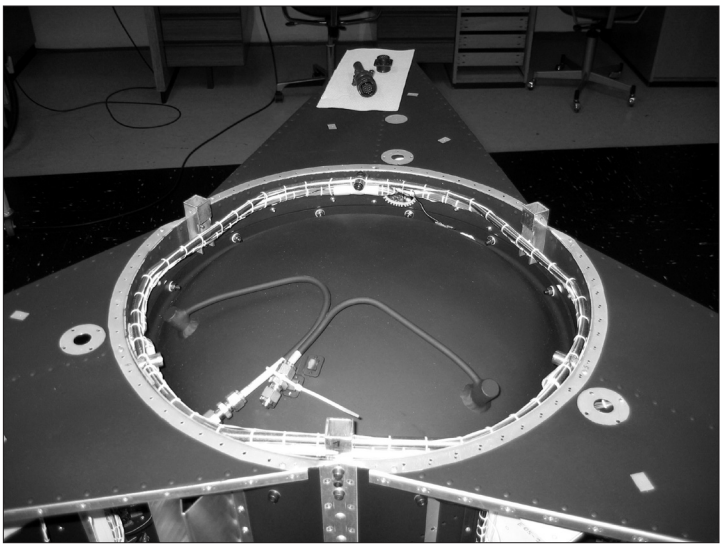


Figure 10: Propellant tank installed in the structure.

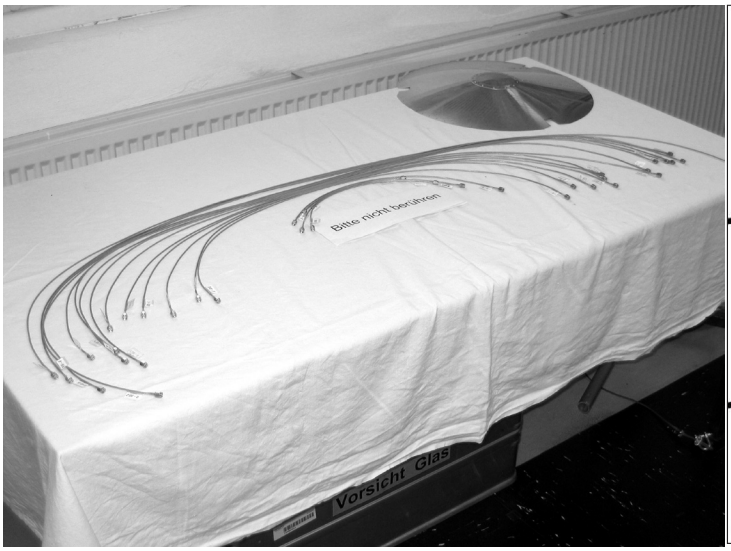


Figure 8: Coax cables ready for installation.

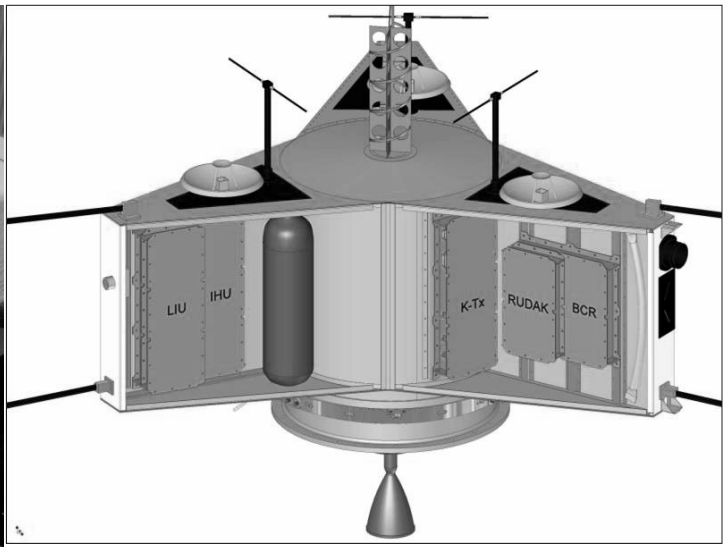


Figure 11: Drawing of the P3E wings shown in the photographs.

Figure 9: Propellant tank in 2005. There is a "Do Not Touch" sign on the propellant tank.

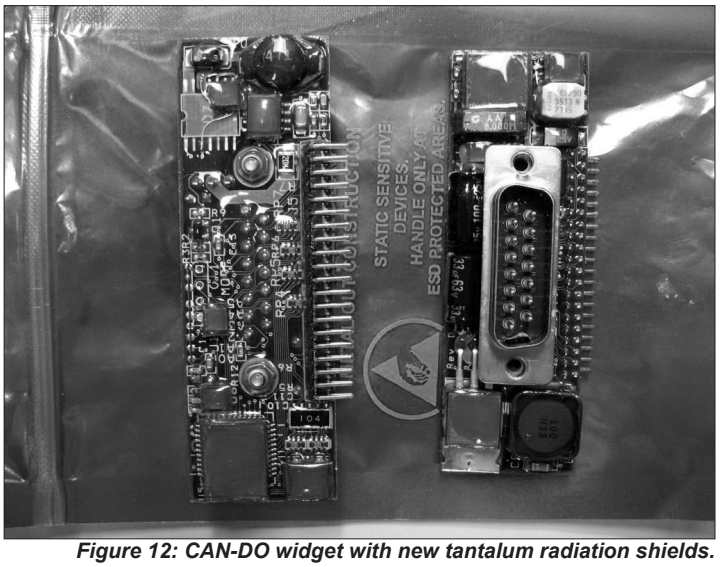


Figure 12: CAN-DO widget with new tantalum radiation shields.

AMSAT Groups Support ZEL Funding

by Trevor, M5AKA

Earlier this year the Directors of AMSAT-DL were informed by the University of Marburg in Germany that it had been decided that funding for the ZEL by the university would cease at the end of 2007. The directors approached AMSAT-NA and AMSAT-UK for financial assistance in keeping the ZEL open for another year. The sum of 25,000 Euros was requested.

At recent meetings of the AMSAT-NA board and of the AMSAT-UK committee, it was agreed that both would contribute to the donation. Given the relative sizes of the two donating AMSAT groups it was agreed that AMSAT-NA would donate 75% of the money required and that AMSAT-UK would donate 25%.

The ZEL (Zentrales Entwicklungslabor fur Electronic, roughly translated as the Central Development Laboratory for Electronics) has been the facility which, over the last 40 years, has been at the center of much amateur satellite development activity by members of the university, members of AMSAT-DL, as well as other members of AMSAT from outside Germany. The most famous satellite to be produced there was OSCAR-13 that gave the Amateur Radio community many years of excellent service.

Currently under construction is Phase 3E, a satellite similar in size and shape to OSCAR-13, but with many advanced features. It will carry a 70 cm to 2 m band transponder, as well as transponders on other bands. Importantly it will carry its own rocket motor which will boost its orbit into a highly elliptical one, which will give world-wide coverage, allowing ordinary radio amateurs great DX possibilities through the transponders. Radio amateurs have not had such a satellite since the demise of AO-40 in March 2004.

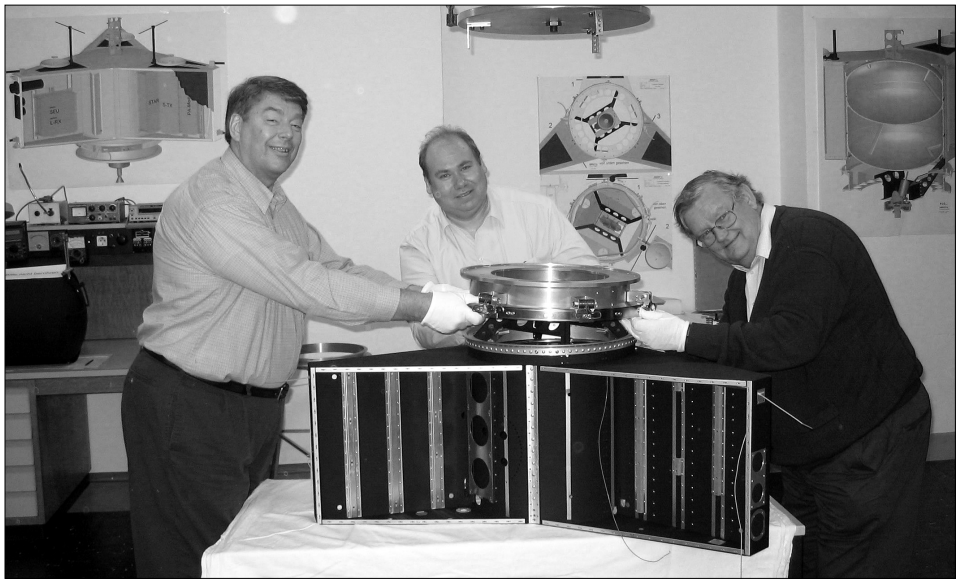
The P3E satellite is still under construction in the ZEL, and its completion is anticipated for sometime in 2008. It is noteworthy that some of the personnel employed by the university to work in the ZEL have undertaken to continue working on P3E as volunteers.

Pictures of the ZEL can be seen at: http://www.uk.amsat.org/gallery2/main.php?g2_itemId=32

AMSAT-UK publishes a quarterly newsletter full of amateur satellite information. Join now online at https://secure.amsat.org.uk/subscription/

For further details contact the secretary Jim Heck, G3WGM

Tel: +44 (0)1258 453959
Email: g3wgm@amsat.org
Web site: http://www.uk.amsat.org/



AMSAT representatives from AMSAT-NA, AMSAT-DL and AMSAT-UK meet at the ZEL with the P3E satellite. From left to right are: Rick Hambly, W2GPS, President AMSAT-NA, Peter Guelzow, DB2OS, President AMSAT-DL, Jim Heck, G3WGM, Secretary AMSAT-UK.

... continued from page 14.

7. To define and institute an optional well-defined standard solution for educational ground-segment hardware (to expedite participation in GENSO)
8. To respect the regulations relating to the use of the amateur satellite service and to encourage the active participation of individual radio amateurs in the network
9. To support the IARU process for frequency coordination

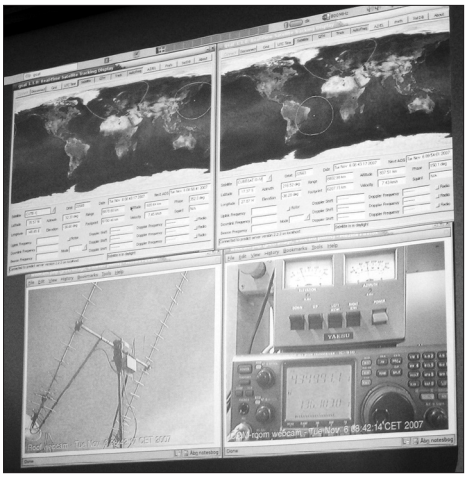
A team from AMSAT-UK (M3RRX, G4DPZ & G3VZV) continues to support this project by developing a standard ground station specification together with a full set of software drivers for the different hardware items that will be used. It is planned that alpha testing will commence early in 2008. Full details can be found at http://www.genso.org/

The European Space Agency (ESA) has published details of the 5th GENSO workshop that was attended by John Rivett, M3RRX, on behalf of AMSAT-UK.

The ESA news item can be seen at: http://www.esa.int/esaED/SEMQM953R8F_index_0.html

M3RRX

Attendees at the 5th GENSO workshop (70 cm antennas in background).



M3RRX

GENSO screen display.

Photo 1: The crowd at the Symposium listens to the Phase IV opportunity.

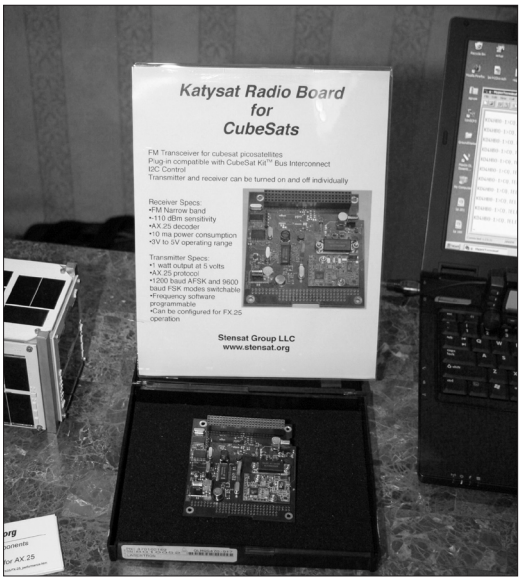


Photo 2: CubeSat radio board ready for the next launch opportunity.

Photo 3: Drew Glasbrenner, KO4MA, conducts a QSO via the Eagle 70cm receiver prototype.

Photo 4: Working hard on the N2SPI Satellite Antenna at the student workshop.

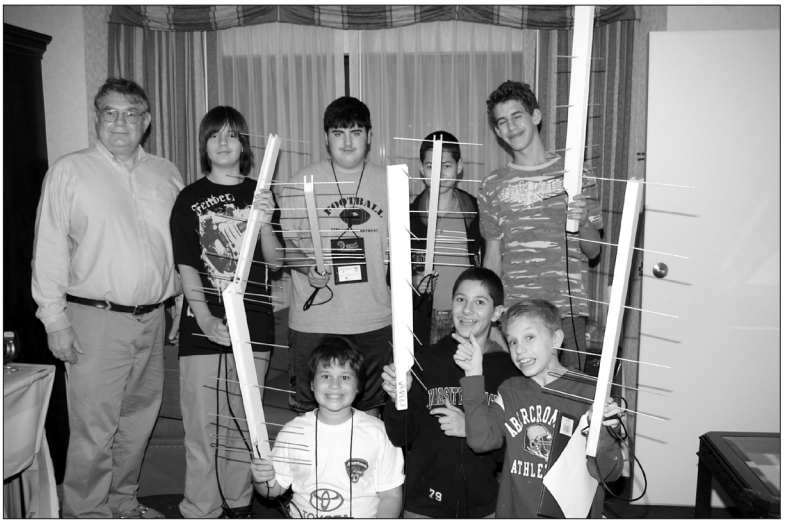


Photo 5: Richard and the team with their completed N2SPI satellite antennas.

Meeting Minutes: AMSAT-NA Board of Directors

8 November 2006

The AMSAT Board of Directors met by 'Teamspeak' Teleconference on Wednesday, November 8, 2006 at 20:00 (8:00 PM) EST to discuss and approve the proposed Memorandums of Understanding (MOU) with Maryland Hawk Corporation and the University of Maryland Eastern Shore (UMES) regarding establishment of the AMSAT Integration Laboratory at Pocomoke City, MD in a building space leased by Maryland Hawk. There was a subsequent discussion concerning the AMSAT Bylaws.

In Attendance:

Barry Baines, WD4ASW (checked in approximately at 21:15)

Tom Clark, K3IO

Emily Clarke, N1DID

Rick Hambly, W2GPS

Lou McFadin, W5DID

Robert McGwier, N4HY

Gunther Meisse, W8GSM, was not in attendance, but Rick Hambly reported that Gunther supports the efforts and MOUs pertaining to Hawk Institute.

Other Attendees:

Andrew Glasbrenner, KO4MA, VP-Operations

Lee McLamb, KU4OS, Executive Vice President

James Sanford, WB4GCS, Eagle Project Manager

Martha Saragovitz, Manager

A number of questions were asked by board members and other attendees concerning various aspects of the MOU, insurance requirements and the types of projects that might be handled at the proposed AMSAT Lab facility.

After these questions were answered, a motion was made by Robert McGwier, N4HY, to "empower AMSAT President Richard Hambly, W2GPS, to conclude the MOUs with UMES and Maryland Hawk Corporation on behalf of AMSAT." Tom Clark, K3IO, and Lou McFadin, W5DID, seconded the motion.

Further discussion followed before the motion was called for a vote. One minor wording change was proposed in both MOU drafts requested by the Board is the addition of the word 'such' in Section 8 paragraph 2 of both documents regarding HAZMAT materials as noted earlier. Rick will confirm that this change is not objected to by either UMES or Hawk Institute and incorporate into the final document. He will sign two copies of each MOU and mail to these copies to the respective representatives of both organizations (Maryland Hawk: Executive Director Ronald G. Bettini and UMES: VP-Planning, Assessment, Technology & Commercialization Ronald G. Forsythe, Ph.D.). Rick will also e-mail the final version to the Board of Directors.

One additional typo correction was found in Appendix A, paragraph 1 fourth line in both documents: change the period following the word 'balloons' to a comma. Rick will incorporate the change and notify his counterparts to ensure there is no objection.

After discussion, the motion was called: "To empower AMSAT President Richard Hambly, W2GPS, to conclude the MOUs with UMES and Maryland Hawk Corporation as amended on behalf of AMSAT."

Roll was taken: by vote of 6-0 the motion was passed. Rick stated that Gunther Meisse, W8GSM, is in favor of signing of the MOUs, but a proxy is not permitted.

New Business:

Robert McGwier, N4HY, proposed that a small committee be constituted to redo the AMSAT Bylaws. According to Bob, Ray Soifer, W2RS, cannot recover the Bylaws that were approved after 1979. The last version that we have on file goes back to 1979 and Bob indicated that there were subsequent changes made that we don't have. He would like to have this committee meet to make changes to the 1979 version and submit to the Board for approval.

Emily, N1DID, noted that there was a 1989 Amateur Satellite Report (ASR) article showing changes in 1988. A subsequent 1989 ASR indicated a one-paragraph change was made in 1989 and Martha has physical copies of these changes. All that needs to be done is to verify whether the Bylaws currently posted on the AMSAT Web site match what Martha has on file from ASR.

Martha then stated that the Web site posting does not have the missing sections that Ray insists were dropped. Bob indicated that his records don't show removal of sections 6, 7 and 8 of the 1979 By-Laws. Ray Soifer, W2RS, insists that the 1989 publication of the Bylaws are correct.

Bob stated that he has no records of removal of sections 6 thru 8 dealing with intellectual property with no vote recorded of these changes either through amendment of the Bylaws or wholesale changes. Martha believes that Ray inadvertently left these sections out and suggested that we put them back into the document. Rick noted that we don't have minutes of the 'semi-annual' BOD meetings which means there is no way to know if the removal of these sections was intentional or not.

Rick gave his support to Bob's proposal for a subcommittee to look at the Bylaws and have this subcommittee make a recommendation to the BOD. The BOD would then vote on the recommendation using the same criteria as amending the Bylaws. The end result would be a current set of Bylaws that has formal Board of Directors approval.

Rick agreed to appoint a committee. Rick asked for a Team Leader. Barry Baines, WD4ASW, as Corporate Secretary volunteered to serve as Team Leader but stated that he would be tied up until after 1 January 07 due to relocation. Bob McGwier, N4HY, and Tom Clark, K3IO, volunteered to join the committee.

A motion to adjourn was made at 21:59 EST by Bob McGwier, N4HY, and seconded by Emily Clarke, N1DID. With no objections, President Richard Hambly adjourned the meeting at 22:00 EST.

Respectfully Submitted,

Barry A. Baines, WD4ASW

Corporate Secretary

Meeting Minutes: AMSAT-NA Board of Directors

5 December 2006

The AMSAT Board of Directors met by teleconference on Tuesday, December 5, 2006 at 20:00 (8:00 PM) EST to decide whether AMSAT should submit a Petition for Reconsideration with the Federal Communications Commission (FCC) concerning orbital debris mitigation.

In Attendance:

Barry Baines, WD4ASW

Thomas Clark, K3IO

Emily Clarke, N1DID

Richard M. Hambly, W2GPS

Lou McFadin, W5DID

Robert McGwier, N4HY

Note: Board Member Gunther Meisse, W8GSM was not on the call.

Other Attendees:

Andrew Glasbrenner, KO4MA, VP-Operations

Perry Klein, W3PK, VP-Government Liaison

Lee McLamb, KU4OS, Executive Vice President

Martha Saragovitz, Manager

Paul Shuch, N6TX Director-Education

Ray Soifer, W2RS

Ray Soifer, W2RS, began by outlining the timeline for reconsideration of the petition and comments. The deadline for filing is 15 December 06. Then, within a window of 10 days starting15 days after the FCC posts our Petition in the Federal Register, we may file a 'Reply to Oppositions' addressing issues raised by commenters as well as any additional points AMSAT cares to add.

Bob McGwier, N4HY, moved to empower Ray Soifer, W2RS, Perry Klein, W3PK, and Rick Hambly, W2GPS, to file a Petition for Reconsideration to drop the Orbital Debris Regulations. Lou McFadin, W5DID, and Tom Clark, K3IO, seconded the motion.

Ray Soifer, W2RS, then provided a history of the orbital debris issue. The FCC's International Bureau stayed the debris language by not including it in the Federal Register. Key timeframes: The International Bureau docket started in 2002. The FCC's Wireless Telecommunications Bureau docket (omnibus) started in 2004. Ray: We believe we have a good chance of getting a stay again. Internally, the FCC's Wireless Telecommunications Bureau may be happy to abandon this proposal and leave it with the International Bureau.

Rick Hambly: The Board will be provided the final text prior to filing.

Attending BOD members voted unanimously to approve the motion by Bob McGwier, N4HY.

The Board of Directors Meeting concluded at 20:33 EST.

Respectfully Submitted,

Barry A. Baines, WD4ASW

Corporate Secretary

Meeting Minutes: AMSAT-NA Board of Directors

6 March 2007

The AMSAT Board of Directors met by teleconference on Tuesday, March 6, 2007 at 20:03 (8:03 PM) EST to approve the revised 2007 budget. Six of the seven directors were present at the start of the call with Emily Clarke, N1DID joining at 20:16.

In Attendance:

Barry Baines, WD4ASW

Thomas Clark, K3IO

Emily Clarke, N1DID (joined at 20:16)

Richard M. Hambly, W2GPS

Lou McFadin, W5DID

Bob McGwier, N4HY

Gunther Meisse, W8GSM

Also on the call were:

Andrew Glasbrenner, KO4MA, VP-Operations

Lee McLamb, KU4OS, Executive Vice President

Martha Saragovitz, Manager

AMSAT Treasurer Gunther Meisse, W8GSM, sent out version 2.0 of the 2007 Budget on 2 MAR 07 via e-mail to the members of the Board of Directors. Gunther noted the following changes in Version 2:

-Line 14 with Eagle Assessment of $100 per person (voluntary) plus letter to Life Members asking for their support of Eagle.

-$16,000.00 reassigned to Lab Refurbishment from three other areas (Eagle Structure, Eagle Payloads, and Eagle Project Management). A Cubesat project with HAWKE is forcing us to finish the AMSAT Laboratory sooner than originally planned. There are no expenditures for AMSAT other than getting the clean room finished sooner than expected. General Dynamics and SpaceX are sponsoring the CubeSat.

-There is a need to upgrade lab equipment – AMSAT will ask for hardware donations to help make it a 'world class' lab in the next few years.

Note: capital expenditures are not included in the Income/Expense statement. This means that the 'cash flow' will be significantly higher.

-Goettler Associates is expected to provide a report in April regarding their assessment of a prospective North American Fundraising Campaign for AMSAT. This will impact prospective expenditures currently in the budget.

-AMSAT reserves are over $500k. If we assume $300k in reserves needed for one year's expenses, then we have $200k to invest. This means that instead of $320k in fund raising in 2007, we must raise a minimum of $120k in 2007 to maintain projects based upon projected spending.

Vote: A motion was made by Robert McGwier and seconded by Richard Hambly to accept the Version 2.0 budget dated 2 MAR 07 as proposed. The Board approved 6 to 1. Emily Clarke voted against the motion, stating that the budget is unreasonable as AMSAT won't reach the stated fundraising goal.

Other Items:

Goettler Associates: The board decided to meet with John Goettler in April 2007 rather than during the 2007 Dayton Hamvention as originally planned. Gunther Meisse, W8GSM, will arrange to set up the meeting in Columbus at the offices of Goettler Associates.

Dayton Hamvention: We need to finalize speakers for the AMSAT Forum.

Second Life. A proposal was discussed to allocate $50.00 in support of Second Life as this venue provides a new way to publicize AMSAT. After discussion, it was decided to table the motion for $50.00 to donate to Second Life.

The BOD Meeting concluded at 21:37 (9:37 PM).

Respectfully submitted,

Barry A. Baines, WD4ASW

Corporate Secretary

Meeting Minutes: AMSAT-NA Board of Directors

1 May 2007

The AMSAT Board of Directors met by teleconference on Tuesday, May 1st at 20:00 (8PM) EDT to consider the fundraising initiative and the information gathered at the fact-finding visit to Goettler Associates in Columbus OH on April 19th and 20th. All seven board members were present on the call.

A motion was made to formally accept with thanks the Goettler Associates Feasibility Study Report (April 2007) that was formally presented to six of the seven BOD members on April 20th in Columbus, OH. This motion was seconded and was discussed. The main concern raised was that the report does not

specifically say over what period of time this fundraising activity will take place. It is the Board's understanding that this will be over a five-year period. The Board voted unanimously to accept the report.

A motion was made by Bob McGwier, N4HY, that the AMSAT National Fundraising Ad-Hoc Campaign Study Planning Committee be empowered to negotiate with Goettler Associates on their proposal for continued use of their services. This motion was seconded by Tom Clark, K3IO, and was discussed at length. The 'Ad Hoc' Committee currently consists of Gunther Meisse, W8GSM, Rick Hambly, W2GPS, Barry Baines, WD4ASW, Tom Clark, K3IO, Walt Wittenburg, K0CEH, and Mal Preston, NP2L. Ray Soifer, W2RS, has been an advisor to the Committee. The Board considered some changes to the makeup and there was concern raised that the committee could become too large to be effective. The motion was unanimously approved with the understanding that the Committee could not commit to spend more money than was already allocated in this year's budget without formal Board approval. The motion was unanimously approved.

The meeting was adjourned at about 21:30 (9:30PM) EDT.

Respectfully Submitted,

Barry A. Baines, WD4ASW

Meeting Minutes: AMSAT-NA Board of Directors

3 July 2007

AMSAT President Rick Hambly, W2GPS, via teleconference, called a Board of Directors meeting that started at 21:22 EDT on Tuesday, July 3, 2007. Present on the teleconference were the following Directors:

Barry A. Baines, WD4ASW

Thomas Clark, K3IO

Emily Clarke, N1DID

Richard M. Hambly, W2GPS

Lou McFadin, W5DID

Robert McGwier, N4HY

Gunther Meisse, W8GSM

In addition, the following officers were on the call:

Drew Glasbrenner, KO4MA, VP-Operations

Lee McLamb, KU4OS, Executive Vice President

Jim Sanford, WB4GCS, Eagle Project Manager

Martha Saragovitz, Office Manager

Rick Hambly, W2GPS, submitted the following motion, seconded by Gunther Meisse, W8GSM:

Motion: To extend authorized funding in the 2007 AMSAT Budget from the current $40,000.00 to $80,000.00 to cover anticipated expenses in 2007 for National Fund Raising and authorize Goettler Associates to engage in their proposal dated June 1, 2007 as reported by the Committee appointed by the Board of Directors to evaluate and negotiate with Goettler Associates for fund-raising services in support of a capital campaign for AMSAT.

By a vote of 7-0, the motion was unanimously approved by the Board of Directors.

In addition, the Board agreed to activate and populate the AMSAT Endowment Fund Committee to carry forward the National Fundraising Campaign.

The meeting of the AMSAT Board of Directors closed at 21:25 EDT on Tuesday, July 3, 2007.

Respectfully Submitted,

Barry A. Baines, WD4ASW

Corporate Secretary

Apogee View

... continued from page 3

traditionally have lower rates of donations but during which we are ramping up our engineering activities and preparing for the upcoming hamfest season. It only takes a few seconds to make a donation through the AMSAT on-line store at www.amsat.org or to call Martha at (301) 589-6062.

Summary

AMSAT needs the support of our membership, including your feedback, your donations and your participation in AMSAT activities. Please become a part of the future by donating some of your time to some AMSAT project or activity.

73,
Richard M. Hambly, W2GPS
AMSAT President

144 MHz Contact Completed by Bouncing Signals from ISS

On the Moon-Net reflector, Bernd, DF2ZC, reports that he has successfully had a CW contact on 144 MHz by bouncing his signal from the structure of the International Space Station (ISS).

The posting says: Triggered by Peter, SM2CEW's, attempts to complete a QSO by using the ISS as a reflector, Frank, DH7FB, and I decided to try that as well.

From Peter's experience (and also Frank's while listening to Peter's tries) we believed it would be worthwhile to consider the BPSK63 mode as this would enable us to exchange all needed contact information within few seconds (using the EME reporting style and QSO rules).

However, during the first tries on 8 December we quickly realized that there was an amazingly fast-changing Doppler shift that makes use of this mode impossible. We returned to good old CW since this is copyable during such situations when you are not 100% tuned on the signal.

The second try on Sunday 9 December during ISS orbit number 51845 starting with a common window at 1626Z, we copied signals at elevations of > 20 degrees and within a minute exchanged all the necessary data. Signal reports were about S3...S5 (DF2ZC was running 300 watts output). It was a tough task to follow the quick Doppler changes and also adjust elevation and azimuth rotators. Two hands is at least one too few.

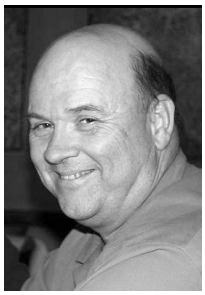
That was a thrill! And now we are celebrating. We will try more QSOs in the coming days.

By the way, http://www.n2yo.com/ gives a nice live Google Earth graphics display of ISS and other satellites.

73,
Bernd, DF2ZC (JO30RN)
http://www.df2zc.de/

Engineering Notebook

Bob McGwier, N4HY, n4hy@amsat.org
V.P. Engineering



I wish to begin my return as scribe of the engineering notebook by extending our sincerest thanks on behalf of AMSAT for the services rendered to us by Jim Sanford during his tenure as AMSAT Eagle project manager and to wish him all the best. Jim ran into life. He has a very busy job, much busier than he anticipated when he "retired" from the Navy. His father, also a ham, who is credited with firing the first shot by the U.S. in World War II has come to live with Jim and Patty after leading a long and happy life but is now in need of assistance. Tom, Rick and I had the honor of visiting Jim and Patty during Mr. Sanford's early days of his new adventure. We thoroughly enjoyed meeting him. Jim's love of the Navy, turning it into a career begun at the Naval Academy, now has a clear starting pointing after meeting Mr. Sanford. Jim has also had to deal with several health issues that have lessened his ability to meet his own very tough expectations of himself. Given all of this, Jim has decided he could not do the project manager job now. I know you will join me in wishing Jim, Patty and Mr. Sanford all the best.

During the past year, the AMSAT team in Pocomoke, Maryland led by Bob Davis, KF4KSS, our lab director who works for the Hawk Space Institute, have brought the lab into full focus. Hawk has built its nice offices in a beautiful facility.

Figure 1: Hawk Space Institute and AMSAT Labs.

Figure 2: Clean room in lab behind offices.

We are just about to get our certificate of occupancy after the fire marshall is happy with the sprinkler system we are installing. When that occurs, the pace of activities at the AMSAT lab will pick up considerably.

This year we will build the Eagle frame. By now everyone knows that we are pursuing the Phase 4 Lite proposal with Intelsat with a vengeance. This does **NOT** mean we are stopping work on the Eagle spacecraft. Lots of the electronics and other communications ideas will have shared hardware and software between the two opportunities. We are doing reuse of hardware and software for both projects.

At the AMSAT labs in 2008 we will take on a large-scale balloon project with the High Altitude Student Payload balloon project.

Figure 3: Visit http://laspace.lsu.edu/hasp

This will give us the opportunity to test our SDX in the form we intend to use on the SuitSat 2 mission this coming year. The High Altitude Student Platform (HASP) is designed to carry up to twelve student payloads to an altitude of about 36 kilometers with flight durations of 15 to 20 hours using small volume, zero pressure balloons. It is anticipated that the payloads carried by HASP will be designed and built by students and will be used to flight-test compact satellites or prototypes and to fly other small experiments.

The SuitSat 2 (and HASP) hardware is coming together. We are doing final testing on the SDX hardware, which is based on the Microchip dsPIC33 and the Flex Radio SDR-1000 mixers (QSD and QSE). We are very grateful to both companies for their support! The RF is close to testing. Microchip engineers and AMSAT engineers have worked together on the experiment control computer, power conditioning system, and the outlook is good for a 2008 launch of SuitSat 2. The proposals for HASP are due December 18 and we will know shortly thereafter if our partners at Hawk Institute and University of Maryland Eastern Shore will be using the AMSAT SuitSat 2 SDX and experiment hardware on this very high altitude balloon.

Intelsat Work

Shortly after New Year's we will begin our design work on the Intelsat payloads and interacting with the engineers building their spacecraft. We are not starting from scratch since most of the communications infrastructure will be based upon elements we had proposed using for Eagle. For the Intelsat payload however, we are expecting to be given three to four times as much power for our payloads than would be available for the entire Eagle spacecraft! This will allow us to emit very large power on the linear transponder downlink as well as the advanced communications payload. On the Intelsat platform, we can use simple antennas and a very simple control computer. No solar panels, attitude control or sensors, batteries, etc. will be needed. Our only jobs will be doing a good communications system and preparing them to survive fifteen years in a geostationary space environment. We are awaiting word from Intelsat on the first technical meetings to be held with their satellite bus manufacturers and the final word on how much money we need to raise.

Recently, I attended the Software Radio Forum technical meetings in Denver. A high-ranking official at DHS gave the keynote speech. They are pretty desperate to find

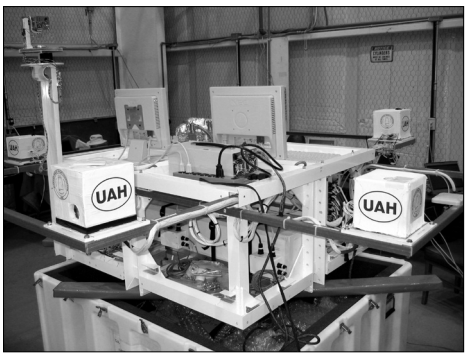


Figure 4: University of Alabama - Huntsville payloads.

a reconfigurable software radio system, with high availability, inexpensive ground terminals for first responders and some ease interoperating with other services. In our favor, we own the spectrum we would use already and in the U.S., the emergency communications uses of the payload are not only legal, they are encouraged. I believe the engineering volunteers of AMSAT, based on the extreme foresight in the use of software radio technology, have positioned our organization perfectly to get the support we need for this payload to reach orbit and live for 15 years! Stay tuned ….

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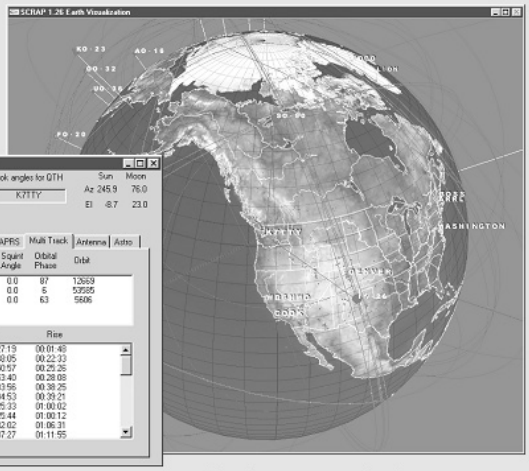
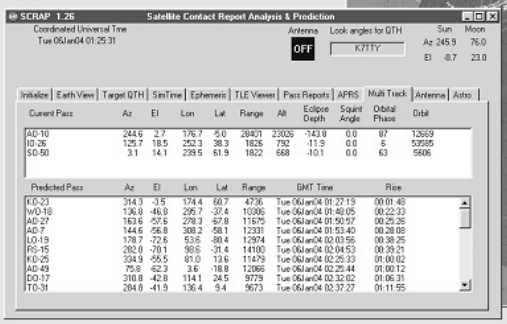
Satellite Contact Report Analysis Prediction

AMSAT is now the North American distributor of SCRAP, a tracking program designed for ham satellite applications for Windows 95+





SCRAP provides a real-time contact report and display for over 2000 satellites on a Microsoft Windows 95+ Pentium platform.

Performance Features

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3. Real-time 3-D visualization
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   c. National boundaries
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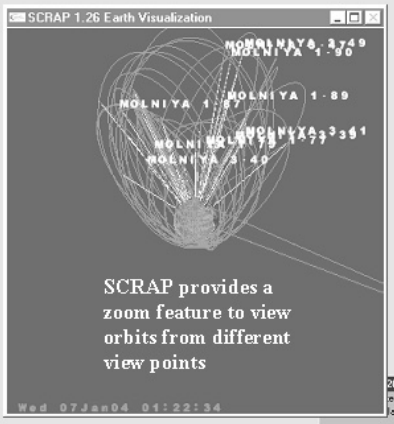
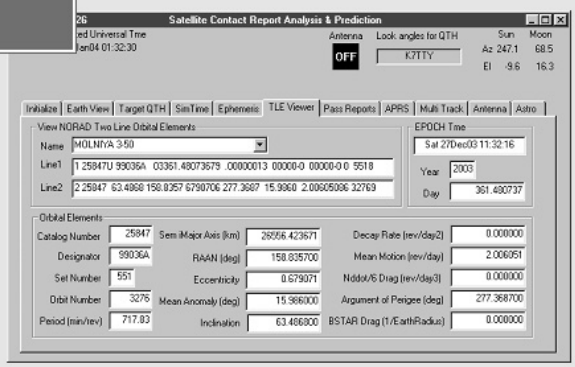
5. APRS station display
6. Multiple ground station support
7. Antenna rotor Az/El control
8. Internet updates
   a. Two line orbital elements
   b. APRS station locations
9. Astronomical data
10. Simulation





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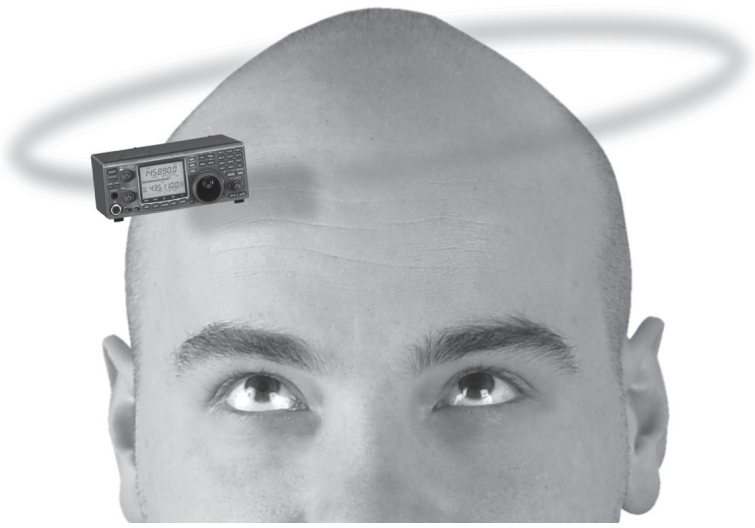
SCRAP is a product of the Bytheway Software Development Lab (BSDL)

Price is $50 for AMSAT members, $60 for non-members, postpaid on CD-ROM. Order by calling 1-888-322-6728, or use the online shop at **http://www.amsat.org**

The author, Bill Bytheway, K7TTY donated SCRAP to AMSAT. All proceeds support AMSAT.

Free software upgrades and further information can be found at **http://www.rtty.com/bytheway**



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